PROCEEDINGS OF THE

AUTOMATIC TEST EQUIPMENT SYMPOSIUM

HELD AT

DAYTON AIR FORCE DEPOT

10, 11 JANUARY 1961

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INTRODUCTION

JOHN W. RIGGS, COLONEL, USAF
CHIEF, GROUND SUPPORT EQUIPMENT I/M DIVISION
DAYTON AIR FORCE DEPOT

INTRODUCTION BY COLONEL JOHN W. RIGGS

We welcome you to Dayton Air Force Depot. It is indeed kind of so many of you to attend what we consider is our most important project.

Being in the service you look over any audience and see many friends and look forward to a get together at coffee break and lunch.

We would like to extend a special welcome to Mr. John R. Taylor, Director of Maintenance Policy, Office of Secretary of Defense. Mr. Taylor's position (GS-18) is the equivalent of the rank of Major General. We are especially pleased that he could find time to attend and hope that he will consider his time well spent. We also welcome Lt Colonel Anthony Quesada, Hq USAF, and Mr. James Grodsky, Office of Director of Defense Research and Engineering, Office of Secretary of Defense.

A luncheon has been planned for 1230 in our cafeteria and immediately following our adjournment today, a cocktail party will be held in the Officer's Club.

I now introduce our Commander, Colonel William W. Veal, who will give you the welcoming address. Colonel Veal came to the Depot last summer as Deputy Commander, taking over as Commander 1 December 1960. Prior to that he served as Deputy Commander of Mobile Air Materiel Area, as well as many other assignments. Gentlemen, Colonel Veal.

WELCOMING ADDRESS

COLONEL W. W. VEAL
COMMANDER
DAYTON AIR FORCE DEPOT

INTRODUCTORY PROLOGUE

John W. Riggs, Colonel, USAF
Chief, Ground Support Equipment I/M Division
Dayton Air Force Depot

INTRODUCTORY PROLOGUE BY COLONEL RIGGS

I am genuinely pleased to have the opportunity to meet with you to discuss the extremely important subject of automatic test equipment. Through personal desire and insistence, I was given my present assignment as Chief, Ground Support Equipment Inventory Management Division. This job offers an unusual vantage point with respect to this great area of automatic test equipment. I wanted this assignment because I believe in the future of automatic test equipment. Automatic test equipment can be a good and faithful servant; it can call out to us areas that need attention and effort; it can caution us where danger may exist and it can reassure us when all is well. Of course there are times when this servant becomes our master; not only telling us that we must do something but, with exasperating precision, telling us that what has been done by human hands is not quite good enough. Automatic test equipment techniques and procedures, however, are a must for the future.

Before I discuss the future, let us review quickly the past and present. Let us look back about 25 years, or about ten years before Worldwar II. At that time, we had great stability in our military personnel and in the weapons and equipment they used and maintained. This enabled us to keep up quite well as technology advanced. But with the magnitude and tempo of the war, large numbers of advanced complex equipments were produced and put into the users' hands so quickly that our technical capability could not match the pace. About the time the war ended, we were almost on top of the problem, but then followed demobilization and the military services were able to retain only a small part of the skills we had worked so hard to create. This would not have been serious except for two new events. We entered the jet age. This was followed quickly by the Korean Conflict. Here again, a multiplicity of complex equipment and crash programs, which again placed into the users' hands equipment that had not been

adequately engineered or service tested prior to production. With the end of the Korean War, demobilization again liberated the skills we had again so painfully and expensively developed and trained.

And now we stand, not on the threshhold, but smack in the middle of the missile age which is again bringing tremendous advances in technology. Almost as if history were repeating itself again, our progress in operational mission accomplishments has raced far ahead of our capability to maintain military equipment in a dependable and economical manner. Even when accompanied by reasonably high orders of skills, facilities, manpower, and materiel, we find limitations in our ability to quickly diagnose equipment circuitry that needs attention, or obtain positive reassurance that all is well with these new weapons and equipment. Looking to the future, automation of our testing operations is a must. Our methods and equipment need further exploratory tests. Oh, we have within our separate organizations made great strides in specific areas. We each have had our fair share of trial and error, and we have each profited by these experiences.

I do not propose that we can solve any automatic test equipment problems in this session. I do believe, however, that our greatest accomplishment can be the establishment of cordial and friendly associations upon which we together can build a communications medium for exchange of information about automatic test equipment to our mutual benefit. We do not know all the answers, but we are firm in the conviction that we are on the right road. I solicit your attention to the fine presentations that will be made during this session. We want to hear your opinions and comments during the discussion period that will follow each of the subjects presented.

I would like to call upon Mr. Norm Smart of our Depot Plans and Management Office who will present a briefing of our Depot operations and give you a preliminary view of automatic test equipment and automation procedures, which we employ here today.

MANAGEMENT BENEFITS THROUGH USE OF AUTOMATIC TEST EQUIPMENT

Frank W. Kyle
Deputy Chief, Ground Support Equipment I/M Division
Dayton Air Force Depot

In this presentation I will discuss: What is automatic test equipment, where we are today using automatic test equipment, its application to depot-level repair, and the management benefits which can be derived from its use.

The increasing circuit complexities in today's weapon systems demand new methods for testing these highly complex devices. Many weapon systems are beyond the specialized repairman's capability because of the magnitude of tests required for the operational analysis. In addition, our technical engineering talent must be directed toward development tasks rather than maintaining our equipment in a ready state.

The Air Force has been expanding its use of highly complex weapons and the requirement for automatic test equipment along with other GSE has become the major cost of the system.

What is automatic test equipment, and why?

Briefly, it's nothing more than manual test equipment that you would use to check out a system, grouped together and programmed through a device by test point selector switches, relays, and transducers, to perform in a logical sequence manual tests in an automatic manner.

Why automatic test equipment?

Uniform Testing

Consistent Quality Control

Enables Faster Turn-Around Time

Higher Quality Product

Logistic Control

Economical in Relation to Job Performed

Dayton Air Force Depot was given the program responsibility in July 1958 to establish an automatic test equipment program for depot-level repair. We have made "management benefits" the target of this program. To reach this target, a study had to be made to determine whether or not test equipment could apply to depot level testing. After determining the feasibility, to what extent could it be applied? Could it be applied to today's systems, or must we design the test points and check-out parameters for tomorrow's systems? After these two phases were accomplished, what would be the effect on the logistics system? On the repair cycle? On the repair time?

A major step that cannot be overlooked is the cost. What will be the cost of applying automatic test equipment to depot-level repair? What effect will automatic test equipment have on total replacement parts cost?

We at Dayton Air Force Depot have had an aggressive program to determine these factors. I'll go through each of them for you and discuss the progress in each area.

The objectives established for our program are "maintain and improve equipment reliability". Build toward standardization in check-out and stimuli equipments. Insure check-out equipments include maintainability and self-check features. Provide the greatest flexibility possible consistent with the requirement, concept of maintenance, and cost. Keep in mind the repair concept of "maximum repair in the field".

We find that today automatic test equipment has multi-applications. Maintenance, in the Air Force, has worldwide responsibility. We are using automatic test equipment for system check-out of ground radars, for shipboard use, for missile count-downs. It can be used for ground communication and has possibilities for fuel flow, hydraulics, and many other areas. You can see that automatic test equipment has possibilities in the majority of our Air Force maintenance work.

On the first rim of our target we had to determine the application of automatic test equipment. Is it actually feasible to check out systems going through depot-level repair with automatic test point analysis? To do this we have obtained test equipment which will check systems of varying complexity automatically. We have programmed these equipments for repair analysis of selected airborne communications equipment. For the purpose of our investigation we selected automatic test equipments in three general categories. We will consider these in dollar categories: \$1-\$10,000; \$10,000 to \$70,000; and those over \$70,000, in original acquisition costs. The equipments selected for the evaluation tests were representative of equipments in their category. We do not say that these equipments selected for the tests are the best; they were equipments available to us to perform automatic check-out work at the time of our investigation.

In the first category of equipment - the \$1-\$10,000 category - we obtained a Robotester. The Robotester was programmed to check out modules of the ARC-27 UHF communications set on a static type test. By static type test I mean the set is turned off. It gives you a resistance type check. With this equipment you have a tape program which gives you a "go - no go" condition as the tests proceed. If it's a "no go", the tester will stop. It will read out the particular test and component which is out of tolerance. This equipment is versatile inasmuch as by new cable hookups and new tapes the sub-modules and control boxes of many systems can be programmed for automatic check-out.

In the second category of equipment - the \$10,000 to \$70,000 area - we obtained a CTI unit, which is a California Technical Industries unit. It, too, is a static type tester that has capabilities for more complex circuit checks such as impedance, reactance, etc.

In the third category we obtained a DATICO, manufactured by Nortronics, which is representative of a highly complex static and dynamic tester. By dynamic testing we mean checking the equipment under actual operating conditions for proper sensitivities, voltages, power output, etc. This tester has multi-capabilities in overall system checks. Other equipments in this same category are the DEE made by RCA, the PATE made by Motorola, the DEMON by Curtis-Wright, the SCATE by Stromberg-Carlson, and the GJQ-9 which is the military spec version of a program comparator.

Now, for the second rim of our target: Where can automatic test equipment be used in depot-level testing?

The initial investigation has been directed toward airborne electronics. The ARC-27 communications set and the IFF APX-6, 6A & 25 series equipments are being service-tested utilizing automatic test equipment repair analysis. Middletown AMA shops are accomplishing pre-production and final repair tests on a compass amplifier. The results thus far indicate applying this test analysis to today's systems can pay dividends in continued equipment reliability, longer mean time to failure, and this results in less mission aborts because of electronic failure.

What has been the effect of using automatic test equipment for test point analysis at depot-level repair.

Initial results of our program show that the repairman checks approximately 15 points in a manual repair operation, whereas through automatic test point analysis we check over 100 points. Both methods of repair are accomplished in approximately the same time -- this was on the ARC-27 --. However, the equivalent repair time is due to the requirement to replace those marginal parts which are coming to their end-of-life cycle, and eliminating the marginal conditions. Many of these marginal conditions - that could be potential early failures - are eliminated during the repair

operation. Repair by automatic test equipment will, we believe, extend the equipment's operation time and reduce aircraft aborts because of electronic systems failure.

At Middletown AMA where they are using automatic test equipment for B-6 automatic pilot amplifier testing, the amount of time it takes to do the repair operation was decreased by approximately 3½ hours (17½ to 14 hours).

What is the cost of automatic test equipment, and the cost of using it in our logistics system? How would it help our Air Force management system?

To determine the actual repair cost versus greater meantime-to-failure and more system reliability, we have a contract with Aeronautical Radio Incorporated to compare equipment repaired manually with equipment repaired by automatic test point analysis.

The ARC-27 - an Air Force high-volume, high-cost inventory equipment - has been our test vehicle. At Lockbourne Air Force Base, which is a SAC base, we are conducting a test wherein equipments repaired by automatic test equipment and manually are installed in B47-KC97 aircraft. During the test, comparisons will be made of equipment meantime-to-failure between manual and automatic methods of analysis and repair, the reliability of equipment during operation, and the accumulation of information to predict failure trends. Test results thus far indicate that we will have a greater meantime-to-failure and more reliability by the elimination of many marginal conditions during the automatic repair cycle. You can recognize the result of improved mission capability at reduced mission cost.

An instance of practical application, using automatic test equipment for a logistics tool, was accomplished at Davis-Monthan Air Force Base. (This is where we send our aircraft for storage and salvage.) The first stage of this program has proved very successful.

With one piece of programmed automatic test equipment technicians were able in one month to complete a normal 10-month workload for a van equipped with manual test equipment and technicians. By the use of automatic check-out equipment to determine serviceability in this Davis-Monthan project, we were able to return ARC-27 equipments to service in the shortest possible time with a high degree of assurance that they would be reliable for operational use. This operation eliminated a large backlog and the need for re-procurement action.

A second phase of this program is now in progress. The IFF series of equipments - APX-6, 6A, and 25 - are being checked for serviceability. The use of automatic check-out equipment for projects such as this certainly is a management tool for our logistics manager to obtain fast turn-around to meet his requirements to using activities.

Our program thus far indicates that automatic test point analysis for depot-level repair is practical. Through the continued tests in operational aircraft with SAC and ARINC we will be able to prove that the cost versus the additional reliability and maintainability will give us improved and economical logistic support.

In our future program, the ARN 21 TACAN (which is Hi-Valu) will be the next equipment programmed for automatic check-out. Automatic test equipment is being planned for use at the Heath Facility where inertial guidance repair and calibration will be accomplished.

Project Pilot Test is now starting at Dayton Air Force Depot; this checks ARC-27 subassemblies, and - through consolidation of serviceable subassemblies - complete sets are assembled. This will produce serviceable equipments in a fast turn-around and define the cause for reparable equipments.

We have arranged with Headquarters MATS to service test tape programs in a field shop environment using the Robotester.

We now have study contracts with Stromberg-Carlson and Nortronics to develop a criteria for determining where we should use automatic check-out equipment. This study will also determine the type stimuli required. (By stimuli we mean the equipment required to generate the necessary test signals for automatic testing.) The results of this study will provide a basis for developing standard specification requirements for automatic test equipment usage.

The study will also develop a model specification for standard stimuli equipment. Standard and versatile stimuli is a "must" in order that the automatic test equipment program can be economical for application to depot-level and field-level repair.

I think you can see from the program thus far that automatic test equipment is an important tool in the hands of the logistics manager. By reprogramming the equipment to new systems, we do not obsolete the test equipment; it can be reprogrammed for the next generation of equipment. It will reduce the amount of peculiar test equipment required. We can realize reduction in the number of stock items entering the management system, reduce storage requirements, etc.

Other possibilities for using automatic test equipment are in the check-out of equipments returned to depots as reparables -- to determine the parts required for the repair and their stock number identification, to identify circuits which have failed (for statistical analysis), to identify for the repairman (and record for him) those marginal conditions which require analysis to insure continued equipment reliability. Automatic test equipment provides a common tool for inspection between the repairman and inspection for quality control.

The logistics manager can use automatic test equipment for projects such as the one we have at Davis-Monthan Air Force Base to obtain fast turn-around or eliminate the requirement for setting up additional repair facilities. Programmed tapes, as a

supplement to our Technical Orders, will insure reliable and consistent field repair methods on a world-wide basis.

All these things and many more are management benefits which we can and will derive through the use of automatic test equipment.

Automatic test equipment can be an important tool in the management of our Hi-Valu logistic system.

HEATH FACILITY

EDWARD JENNINGS

Inertial Guidance Project Office

Directorate of Maintenance

Dayton Air Force Depot, Dayton, Ohio

HEATH FACILITY

INTRODUCTION: For those of you in attendance who may not be familiar with the Heath Facility, I would like to take this time to present the facility's intended mission, location, description of the building, and planning dates on which operation will begin.

MISSION: The Heath Facility will be jointly utilized by two organizations. They are the USAF Standards Calibration and Certification Division and the Inertial Guidance Specialized Repair Activity.

The USAF Standards Calibration and Certification Program is directed by Dayton Air Force Depot. Detachments are maintained at both Boulder, Colorado and Wright-Patterson Air Force Base here in Dayton, Ohio. This organization has world wide responsibility for calibration and certification of all Air Force Standards. With the advent of new weapons systems, especially missiles, which will utilize such guidance systems as Inertial, Infrared and Celestrial Trackers, new requirements are generated. To meet this new challange the Heath Facility, due to its high order of seismic stability, will be modernized to provide a light tunnel for infrared and star tracker calibration as well as suspended platforms with extreme stability for calibration and certification of inertial components. A special room for dimensional calibration of such items as gage blocks and angle measurement instruments is also to be provided.

The Inertial Guidance Repair Activity will perform single point organic specialized repair for stable platforms and its components, the associated gyros and accelerometers. Weapons to be supported initially include the Atlas, Titan, Minuteman and Hound Dog. Planning is also being accomplished for repair of the GAM-87 Sky Bolt. All repair for these systems will be on a repair

and return basis. The average check-out time per stable platform, utilizing conventional equipment is one hundred and twenty (120) hours. A total of Two hundred and thirty (230) platforms per month will be repaired through July 1964. A work-load of this magnitude will require approximately thirty-five (35) complete test consoles. Therefore, it is in this area that we believe VATE will be most beneficial. A more detailed explanation will be given by Mr. Critz, our VATE monitor.

LOCATION: The Heath Facility is located in southeastern Ohio near Newark.

BACKGROUND AND STATISTICS ON BUILDING: Originally the Plant, known as Air Force Plant #48, was intended for use in the Heavy Press Program. This program, which was later terminated, provided a capability for stamping of large wing spars such as those used in B-47 aircraft. The one story steel framed structure contains approximately 396,000 square feet. It has two pit areas which are each approximately 60 feet deep.

CONSTRUCTION: Modernization of the building, which up to this time has been unused, will be accomplished by construction programs being handled by the Navy. Final designs have been submitted and it is anticipated that construction contracts will be let during February with actual construction beginning in March of this year.

PLANNING DATES: Present Calibration and Certification planning is for some calibration equipment to be placed in the building during construction. Other equipment will begin transfer in January 1962. Installation and check-out of new equipment will begin in March 1962. This will take approximately ninety (90) days with the operational date being 1 June 1962.

Inertial Guidance Repair will somewhat parallel Calibration in that installation and check-out is scheduled for February 1962 with the repair of Inertial Guidance Systems to begin in this order:

ATLAS (SM-65)	1 June 1962
MINUTEMAN (SM-80)	1 June 1962
HOUND DOG (GAM-77)	1 July 1962
TITAN (SM-68)	1 September 1962
SKY BOLT (GAM-87)	1 May 1963

VERSATILE AUTOMATIC TEST EQUIPMENT (VATE)

J. P. CRITZ

Interial Guidance Project Office

Directorate of Maintenance

Dayton Air Force Depot, Dayton, Ohio

WHAT IS VATE?

As the Dutchman might say "VATE is vot broke der vagon down". Or if your history lead you through military experience in WWII, you'll remember "HURRY and VATE". Around this Depot you'd think it was WWII all over again, due to the priority and condensed schedules imposed upon the much emphasized VATE program. "HURRY 'N VATE" are synonimous in our Maintenance Directorate language today.

VATE stands for Versatile Automatic Test Equipment specifically for application to depot level check-out of IGS. This name was attached to the program in Aug 60 and will probably remain until a better or more appropriate title is conceived.

WHY VATE?

This is a question a good manager might ask in both senses of the word, or from the Dutchman again "Vot are ve VATING for? As Mr. Jennings has indicated, VATE is primarily conceived to capitalize on the commonalty found in the several peculiar Automatic Test Equipments (ATE's) designed by each of the Inertial Guidance System (I.G.S.) contractors to support their individual system. You might ask, why do we at (DAAFD) wish to venture into this extremely exacting science, when the I.G.S. contractors of necessity, have already blazed their own individual trails? Some would call us daring, others presumptive, but this is the challenge the Air Force is accepting, and the following are some of the reasons:

1. If we don't start somewhere along the line, we'll never be ready for that next I.G.S. system. As many of you well know, support equipment, in many cases, requires longer lead times than the equipment supported. Therefore, well designed adaptable and versatile test equipment should materially assist us in avoiding maintenance support headaches, without retarding technological advances of the equipment supported.

2. Individual people, and individual contractors (by being individual) will always approach a problem differently. Each approach will have its good points and its areas of compromise. Through combining the best from each, the Air Force should be in a position to materially improve the overall approach. In all fairness, one might ask here; after we've standardized this equipment, would we not rule out the diversified approach and thus directly lead to stagnation? But a little further thinking will allay this fear, since the advent of new I.G.S. systems to be checked out will always bring new requirements and standards, which must be answered with equivalent resourcefullness, growth and continued integration of design. Furthermore, recognizing that the first generation of VATE will only realize a small fraction of the total potential of the ultimate standardization goal, much emphasis will continually be placed on development and growth of VATE.

A LOOK AT THE VATE PICTURE

At first glance we can see a large potential saving in floor space. A fully integrated, centrally controlled, and time shared VATE, in lieu of many diversified individual ATE'S (for I.G.S.), cannot help but yield substantial gains in overall management efficiency, production control and training. In short, VATE demands the best in total depot management efficiency. But, here we are too anxious to go immediately into the future. VATE is not here yet. We believe it is just around the corner (about a year and a half). But it's not here today, so the Air Force must buy a first round quantity of Contractor developed ATE's to meet the first work load requirements of Heath to the schedules mentioned by Mr. Jennings. This means, that at least four of the first five I.G.S. (namely Minuteman, Atlas, Hound Dog and Titan) will be initially supported at Heath with peculiar ATE's.

VATE CANNOT BE JUSTIFIED ON IMMEDIATE SAVINGS

VATE is the vision of the long-range planner. It is the payoff for future peculiar ATE equipment not needed. It is a necessary initial step toward ultimate integration of single purpose Depot maintenance.

A GLANCE AT SOME OF THE POTENTIAL SAVINGS

1. It will save many dollars ($$$) in the ultimate requirement for less test equipment hardware.
2. It will save much in manpower and training which would have been required to man the peculiar test equipments.
3. It will save time by streamlining the whole Heath Check-Out operation.
4. It will save much more time by consolidating technological advancements in Inertial Guidance Test Procedure.

HOW COMPLEX ARE INERTIAL GUIDANCE SYSTEMS?

How long would you say it takes to check out an acceptable Atlas I.G.S. at the factory? Those who actually know will please refrain from stating it at the moment. It's around two-hundred (200) hours. Now remember that's when everything works. So, when platforms sub-systems, groups, units, modules or components fail, you may have all, or a large portion of the two-hundred (200) hours to run over again.

A General Motors Executive who directs the design and manufacture of one of our major I.G.S., stated recently that the manufacture and check-out of one (1) I.G.S. gyro, is ten (10) times more difficult technically than designing and building a new model Cadillac.

Furthermore, there are two (2) distinctly different 'breeds of cats' in gyros. The gyros that we have long known and used in autopilots and gyro compasses are

many times less perfect than IGS variety. If one were to compare the excellence of workmanship and function of a Model T Ford with a Rolls Royce, one would still be far short in the actual gap between the autopilot gyro and the IGS gyro.

WHAT IS OUR CONCEPT OF THE FIRST GENERATION VATE?

The overall IGS check-out problem is of such a degree of complexity, that we feel we must go cautiously on a 'first things first' basis. We are aiming toward matching step by step the check-out procedure which has been, or was to have been done by the individual IGS contractor designed peculiar ATE equipment for each system that VATE will replace.

Since no known IGS contractor has integrated peculiar ATE to include more than one general type of test such as Diagnostic Check-Out, Platform, Alignment, or Gyro Test, etc., we feel we should only attempt to integrate Diagnostic Check-Out, Platform Alignment, and Vibration in the First Generation of VATE.

WE RECOGNIZE THE IMMEDIATE CHALLENGE FOR SECOND GENERATION VATE GROWTH

The following represent some of the more fertile areas of growth:

1. Reducing Test time after sufficient correlation guarantees equivalency with the complete test.
2. Integrating, combining, and developing improved Gyro and Accelerometer testing.
3. Employing Operational Analysis and Systems Engineering as well as Job Methods Analysis to all steps and phases of IGS check-out, as well as to VATE itself.

VATE TIME TABLE

Now that you have heard the What, Why, How Complex, and the Caution of our approach, we will reveal the When by exhibiting a brief time table with a general statement concerning each major date.

1. June 1960 - The Commander of AMC (Gen. Anderson) issued notice to all Centers, AMA's and Depots within AMC that DAAFD was to go with the Heath SRA.

2. July 1960 - The Director of Maintenance at Hq AMC (Gen. Bell) directed DAAFD to take every possible step toward standardizing test equipment at Heath. This was interpreted to mean, go with VATE!

3. Aug. 1960 - The commander of DAAFD appointed an "ad hoc" committee to assure complete coverage during the initial stages of implementing the Heath SRA, until the Inertial Guidance Project Office could hire sufficient personnel to continue this management.

4. 3 Oct. 60 - An RFP was released to two-hundred (200) prospective VATE contractors.

5. 17 Oct. 60 - A Bidders Conference was managed jointly by DAAFD Maintenance and Procurement to provide the industry with clarification of doubts as to the intent, means, and extent of the Work Statement for VATE. This was attended by approximately one hundred and forty (140) people representing ninety (90)contractors. All questions were required in the written form, signed by the name of the individual and firm represented. Some of the questions were answered verbally (as time allowed) during the bidders conference. All questions were answered in writing and distributed to bidders along with a revision to the RFP Work Statement which was an outgrowth of the conference.

6. 14 Nov 60 Fifteen (15) Preliminary Proposals were received from individual and teams of bidders. There was a substantial response from both the IGS renowned type bidders, and from renowned ATE type bidders.

7. Total Technical and Procurement Review of the proposals is nearing completion.

8. 20 Jan. 61 is the target date for writing contracts with all IGS contractors for data needed, but not yet obtained, for the VATE Design.

9. 1 Feb 61 VATE Phase I Study contracts are scheduled for release to from two to four prospective VATE contractors entering the final competative effort before the first generation VATE hardware contractor is selected.

10. 4 Feb 61 DAAFD VATE Engineering teams will complete preliminary investigations of the VATE data situation at each of the IGS contractors plants.

11. June or July 61 Phase I proposals will be due at DAAFD for the final evaluation.

12. Sept. or Oct. 61 Award of VATE hardware contract to the winner of the Phase I study contract effort. Note: Outside technical assistance will have been obtained to assure a well balanced and thorough evaluation of the Phase I studies.

13. Twelve (12) to Twenty-Four (24) months later: VATE Hardware should be available. The large varience is accountable the degree of conservatism employed by the selected Bidder.

You have been told generally the What, Why, How Involved, How and When of VATE. Are there questions? If so, will you please state your name and agency represented, so that a complete summary of all questions and answers may be mailed to you.

Thank You

"AN/GJQ-9"

THE COMMON FACTOR OF AUTOMATIC CHECKOUT

WRIGHT AIR DEVELOPMENT DIVISION
GROUND SUPPORT EQUIPMENT ENGINEERING DIVISION

PRESENTED BY: William K. Barton, WWDNCC

THE COMMON ITEM OF AUTOMATIC CHECKOUT EQUIPMENT

The common factor of automatic testing is the programmer-comparator. It consists of the best and essential characteristics of manual testing and the digital computer packaged in accordance with the best in the state-of-the-electronics science.

Did you ever consider the test problem in more abstract and general terms than the usual "Why doesn't this thing work?"

Consider the block diagram of Figure I. The blocks inside the big circle are the essential functions common to any testing problem.

The stimulus block connected by the dotted line is a variable function and may or may not be required depending on the complexity of the test and the complexity of the system under test.

The system block can represent a simple battery, a complex communications set, or a super-complex weapon system. In any of these cases, the functions in the big circle remain the same and only the magnitude of the various functions varies.

Consider now a comparison of the Digital Computer and the Programmer Comparator as exemplified by the AN/GJQ-9 (or DEE or SCATE, etc; they are all essentially the same.) We see that both incorporate programming, switching, comparison, and decision capabilities . Each possesses flexibility and memory; however, it is noted that the PC has less extensive capabilities in these areas. The DC has no measurement capability. This is the chief difference between the two. On the basis of this, they appear to be almost identical but they are not.

Consider one other aspect of each; that is, the nature of the problem each is intended to solve. Here the difference begins to be more apparent. It is seen that the DC is a tool for use in the solution of mathematical problems whereas the PC is a tool for the solution of a physical problem.

The fact that the particular test problem can be stated in terms of mathematical equations is what makes it possible for the DC to be adapted for use in the solution of the physical problem. The PC on the other hand is not so readily adapted to solution of mathematical problems of the type which the DC solves so easily. Rather, it is a specialized version of a DC with the necessary additional equipment which permits it to solve the test problem.

Let us take a look at the family tree of the modern day PC and see what characteristics of its ancestors it has and why. You will note that only the PC is considered because it incorporates the five functions common to the general testing problem. Stimulus equipment which is a variable item is not considered at this time.

We have taken from the technician, manual test equipment, and the digital computer, the best characteristics of each to obtain a superior test device.

Man is the best general purpose testing device yet produced because he incorporates flexibility, extensive memory, and has thinking capability. Where the tests to be conducted are diverse, sporadic, and do not necessarily require speed and exact repeatability, the man can not be surpassed. However, man is slow, can be most inaccurate and is quite error-prone.

On the credit side of his ledger, the man, due to his thinking ability, possesses excellent programming and decision making capability. It is to be noted that he also possesses two other essential-to-the-test-problem capabilities - switching and comparison.

Manual test equipment possesses one essential capability. That is measurement. It also has extreme flexibility due to the fact it can be so readily switched. These same two characteristics also appear on the debit side of the ledger, however. The flexibility and ease of switching of manual equipment, together with the error proneness of man, readily permits errors.

The digital computer possesses several of the essential characteristics, programming, switching, comparison, and decision, but in considerably lesser degree than these same characteristics possessed by man. Also, the DC has the advantage of speed and accuracy of a much greater degree than that possessed by man. It has been demonstrated that the DC is more reliable than man in the long, drawn-out, day-to-day performance of a routine, boresome task.

Under each of these ancestors of the PC is to be seen the characteristic of flexibility. Although it is not an essential characteristic to the testing problem, one would nevertheless think it is a desirable feature and in proper context, it is. It is also seen that this same characteristic can be an undesirable feature. As stated in the case of the technician and manual equipment, flexibility tends to foster inaccuracy and consequent loss of time due to the error proneness of man. Likewise, in the case of the DC, its flexibility tends to generate unnecessary work and introduces undesirable possibility for introduction of errors into the test problem.

The programmer-comparator is a combination of the best characteristics of the three. In addition to the essential characteristics of the test problem, it also has speed accuracy and dependability plus an optimized flexilibity.

Despite all this superior capability, the equipment which results is still subservient to man and will perform no better job of testing than man will permit. This comes about because the machine performs no action that man has not directed that it accomplish either through a manual control panel or through the program stored in the punched tape which directs the efforts of the machine.

This leads to the question "If it is no better than man, why have it?" The answer is that man at his best is far superior to man at his average. Consequently, in preparing a program for use by this machine, we must insure that the best possible effort is put forth by the best qualified people. In this way, the machine can do a job of

testing equal to the best technician each and every time it conducts a test.

The flexibility afforded by the PC is limited to exercise within the bounds of the problem it is designed to solve, i.e., the testing of Air Force equipment with characteristics expressible in electrical terms.

AN/GJQ-9 CHARACTERISTICS

1. Self Checking Characteristics
    - A. Verification of Tape Decoding
    - B. Verification of Each Logic Switching Action
    - C. Self Fault Isolation
2. Measurement Capability
    - A. D. C. Volt 0 - 1000
    - B. A. C. Volt 0 - 350 rms (500v peak)
    - C. Volt Ratio 0.1 - 500 (Reference Range)
    - D. Resistance 0 - 1 megohm
    - E. Frequency - 0.1 cps - 1.0 MC.
    - F. Time - 0 - 100 seconds
3. Test Point Selection
    - A. Basic - 200 channels
    - B. Optional - 201 - 2000 channels
    - C. All channels either ON-OFF or Analog.
4. Stimuli Control
    - A. Basic - 100 channels
    - B. Optional - 101 - 300 channels
5. Power Requirements - either

    115 volts, 60 cps, single phase

    115 volts, 400 cps, three phase

6. Application

   A. Depot

   B. Shop

   C. Flight line

DIGITAL COMPUTER VERSUS PROGRAMMER COMPARATOR

Characteristics	DC	PC
Programming	Yes	Yes
Switching	Yes	Yes
Measurement	No	Yes
Comparison	Yes	Yes
Decision	Yes	Yes
Flexibility	Yes	Limited
Memory	Extensive	Limited
Normal Use	Math. Prob.	Phys. Prob.

AN/GJQ-9 STATUS REPORT

Development - Autonetics Division of North American Aviation, Incorporated.

Production -

Specification - MIL-P-26664, 16 February 1959.

Contract - Bendix Support Equipment, AF33(600)-41492, 10 May 1960.

Preproduction Testing -

High Temperature - Complete
Low Temperature - Complete
Altitude - Complete
Sand & Dust - 10 Jan 1961
Life & Reliability - 29 Jan 1961.

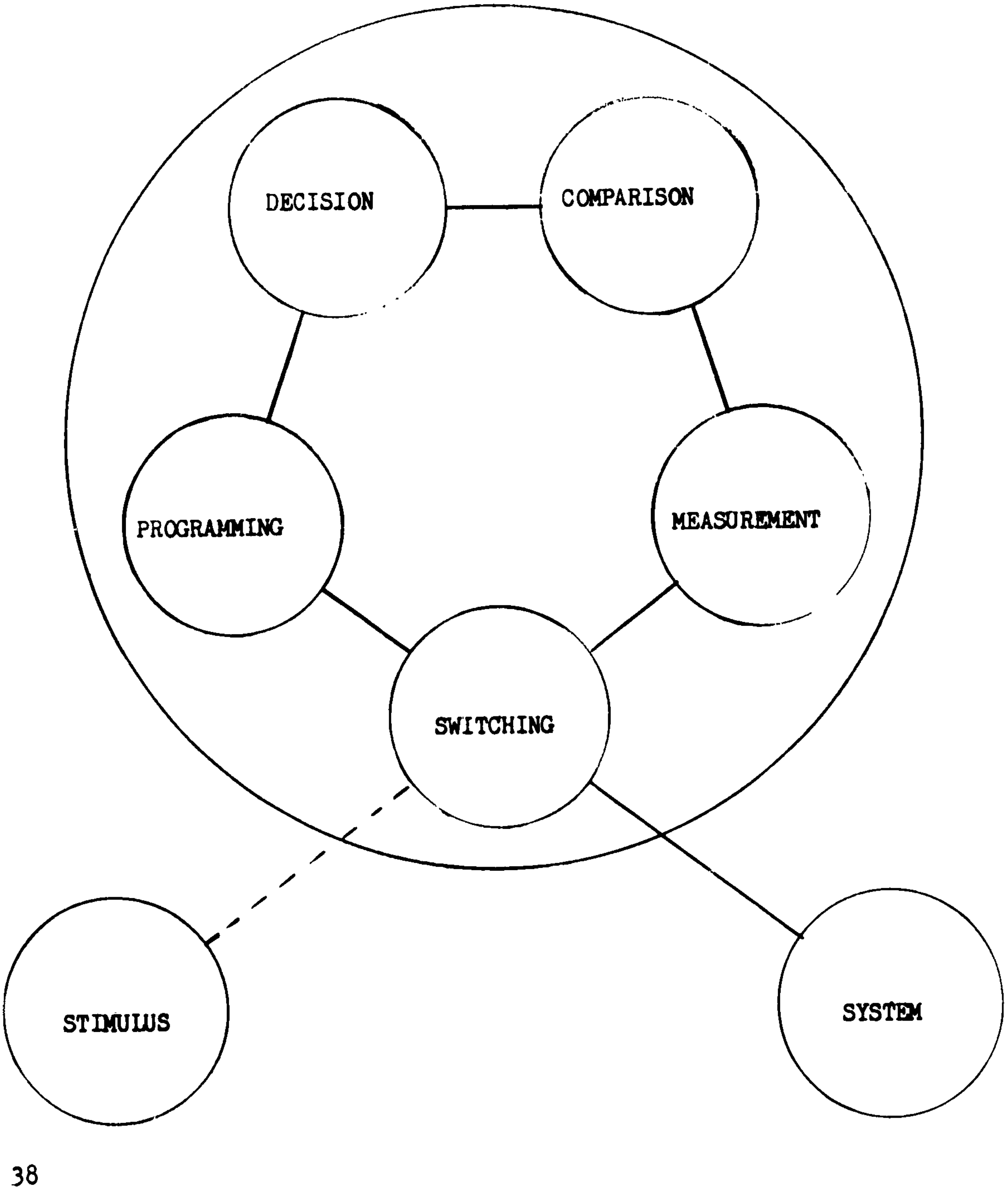
Serial No. 1 - Shipped 5 Jan 1961
Serial No. 2 - In test - to be shipped before February 1961
Serial No. 3 - In assembly

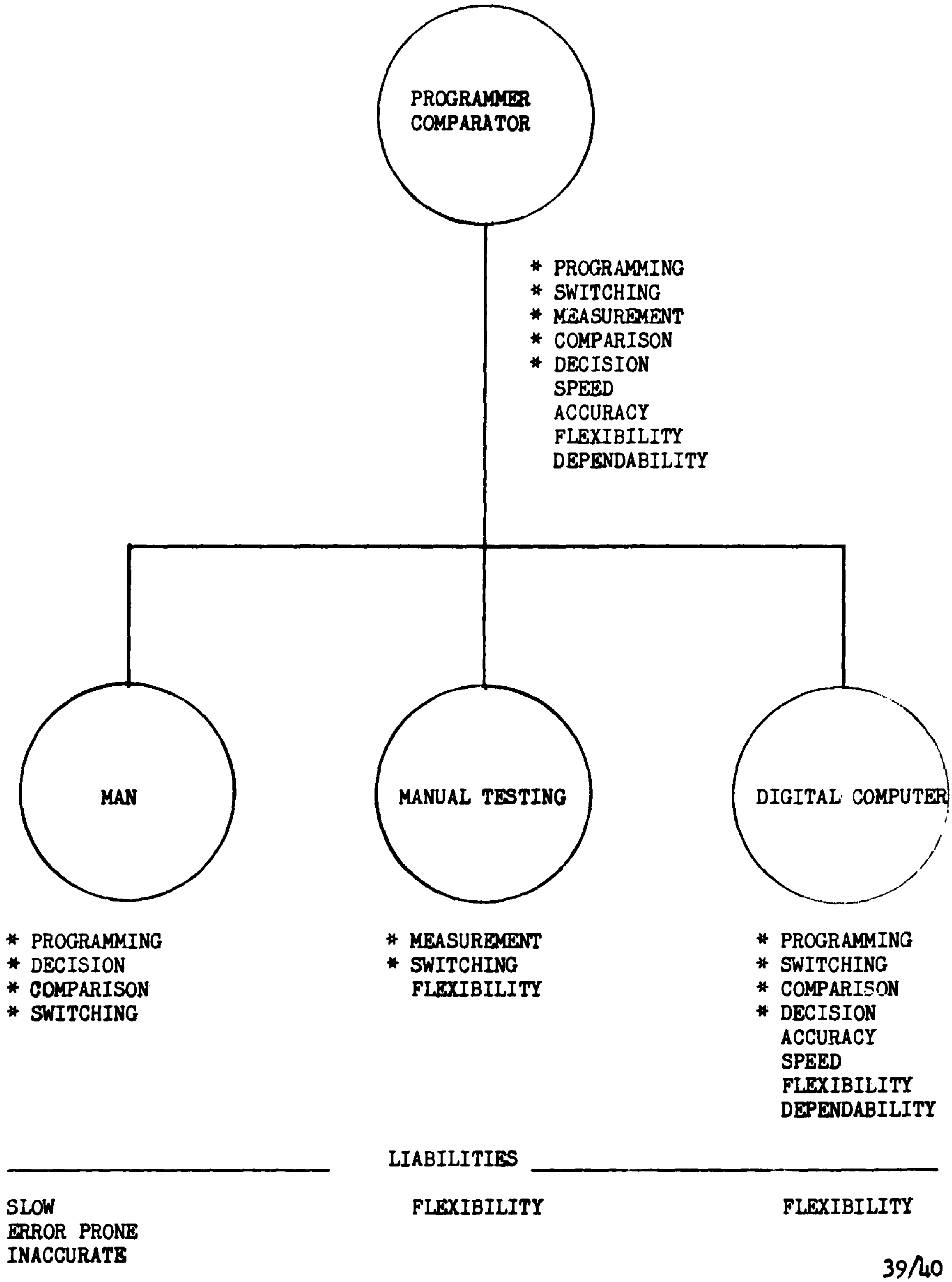
Schedule - 2 months behind

Future Plans -

4 digit readout
AC accuracy
Product Improvement Program

THE TEST PROBLEM




PROGRAMMER COMPARATOR
* PROGRAMMING
* SWITCHING
* MEASUREMENT
* COMPARISON
* DECISION
SPEED
ACCURACY
FLEXIBILITY
DEPENDABILITY
MAN
MANUAL TESTING
DIGITAL COMPUTER
* PROGRAMMING
* DECISION
* COMPARISON
* SWITCHING
* MEASUREMENT
* SWITCHING
FLEXIBILITY
* PROGRAMMING
* SWITCHING
* COMPARISON
* DECISION
ACCURACY
SPEED
FLEXIBILITY
DEPENDABILITY
LIABILITIES
SLOW
ERROR PRONE
INACCURATE
FLEXIBILITY
FLEXIBILITY

AUTOMATIC TEST EQUIPMENT OBJECTIVES

John W. Riggs, Colonel, USAF
Chief, Ground Support Equipment I/M Division
Dayton Air Force Depot

INTRODUCTION:

During the morning session, you have heard interesting presentations about

Management Benefits of Automatic Test Equipment

Utilization of Automatic Test Equipment for Inertial Guidance Repair

Status Report on the AN/GJQ-9

In the remaining few minutes before we close for the day, I would like to tell you more about our Automatic Test Equipment Evaluation Program here at Dayton, and explain our program objectives.

TEXT:

In July 1958, Hq Air Materiel Command directed us to "establish and control a program to ascertain the extent Air Materiel Areas and AF Depots may use automatic electronic test equipment in promotion of efficient and economical maintenance of weapon system equipment". To do the job directed by our Headquarters, we established eight objectives. Later presentations will describe specific actions we are taking to achieve these objectives. I would like to acquaint you with our program and speak briefly about our eight objectives; what they are; why we consider them as objectives; and where we are going.

(1) Familiarization

(2) Application

(3) Reliability

(4) Versatility

(5) Standardization

(6) Training

(7) Integration of automatic test equipment diagnosis output with supply EDPE procedures.

(8) Expansion of program to other Air Materiel Command organizations.

Our overall progress to date has been so significant that we have promised the Strategic Air Command that within one year we could estimate and provide backup data regarding operational use of automatic test equipment in their Command. Within the next six months we will provide them with sufficient information to permit their preliminary thinking in this regard.

WE ARE MAKING PROGRESS

Address by:

Mr. David M. Goodman
Director, Project SETE

at

GENTILE AUTOMATIC TEST EQUIPMENT CONFERENCE

Dayton Air Force Depot

January 10-11, 1961

SETE 119/15

It is my purpose today to talk to you about electronic test equipment as we see it at Project SETE. There is no official status or official backing to what I have to say; the views expressed represent my personal opinion. However, as many of you know, Project SETE has been involved in this subject now for 4½ years and we have developed a perspective in this field which is of some value.

To help put my remarks in order I have distributed three documents which I hope you have had time to review. The first document is a copy of remarks which I made here at the Gentile Air Force Station in February 1959 at a conference which discussed the now popular subject of automatic electronic test equipment. Summarizing that speech I commenced by explaining the background of Project SETE and I explained that one of the purposes of the Project was to obtain, tabulate, and redistribute technical information pertaining to the research and development of electronic test equipment. I indicated the areas in which we were successful, namely that of data collection and distribution, and I indicated the areas in which we were unsuccessful, so to speak.

I also discussed the then-proposed Third Test Equipment Symposium which was to be sponsored by Hqs. ARDC. One major objective of that symposium was to provide a meeting place where forthright evaluation could take place of the then-existing large automatic electronic test equipment programs. Another major objective expressed at that time was that of focussing attention on both the technical and the management aspects of providing electronic support equipment. Despite our efforts it was not possible for us to arrange an evaluation type meeting. It was possible however to achieve the second objective. The results are significant, and appear reprinted in my Conclusions and Recommendations to the Third Test Equipment Symposium, which is the second document which I have distributed to you. With a finite number of exceptions, most of which have been discussed here at this

conference, the remarks contained in my address and the conclusions and recommendations apply with equal force and vigor today.

Having thus achieved the second objective of focussing attention on the technical and management aspects of electronic test equipment we decided at Project SETE that perhaps we could obtain the evaluation in which we were so much interested by some other means. We set out to do this via our Design Course on Automatic Electronic Test Equipment. I think we were very successful and for that reason I have reprinted and distributed the Opening Remarks which I made at the Design Course. I will dwell on this topic for a moment. The program ran for five days. The morning sessions ran for 2-2½ hours and the afternoon sessions ran for 3-3½ hours. Three volumes of lecture notes were prepared and distributed, two of which were available before the Design Course. The material that was discussed was presented in sufficient depth so that a complete understanding of the various test systems was made possible. The purpose of the Design Course was in line with the objectives of Project SETE, namely, that of distributing and disseminating, on a timely basis, significant technical data relating to research and development of automatic electronic test equipment.

It is hard to tell, at this moment, just what the effect of that disclosure will be, but of one thing we can be certain - it will do no harm. What we achieved was a "breakout", a separate description, of test programs which were developed for large and complex equipments under systems concept and which otherwise might not have been reported. In addition, and even more significant, a form of evaluation took place in that I selected each and every one of the test systems that was presented. You all know the difficulty with which such an evaluation can be made. The difficulty resides in lack of measured performance data, shortage of documentation, an excess of sales promotion, a natural lack of objectivity on the part of the engineers describing the fruits of their labor, etc. Despite these problems

we know at this time, that through a fortuitous chain of events, we overcame these difficulties. It was for this reason that I chose to open the Friday morning session of the Design Course with a repetition of my opening remarks. It was more acceptable to the audience at the end of the program than it was at the beginning. Further, there is a strong possibility that the course will be repeated.

In addition to promoting large scale information exchange programs of the preceding types, we have been conscientiously directing our efforts towards making Project SETE a central clearing house of technical information in this area of Electronic test, checkout, and support equipment. We are in the position, presently, of having complete and up-to-date documentation on all commercially available electronic test equipment. From time to time we focus our attention in specific areas of this vast field to generate reports. Some of the reports are made upon request. Others are project generated. Some of the recent studies are in the field of digital voltmeters, sensors, synchro-servo-gyro testers, continuous line recorders, frequency synthesizers, noise generators, etc. We screen the ASTIA Title Announcement Bulletins and have obtained copies of every significant report that is available to us. We have a complete file on Air Force Technical Orders in the 33 category, which covers electronic test equipment. Some of you would be amazed to know how much information is thus made available. We also have many Army Training Manuals, Navships documents, BuOrd descriptive data sheets. We have a substantial number of interim progress reports, development status reports, and technical evaluation reports. This is a voluminous amount of material. The staff of Project SETE, which comprises myself, five engineers and three secretaries, spends a good portion of their time in reviewing these documents, and in arranging them so that the material contained therein can be retrieved accurately and efficiently. We have worked out an interesting system of coding our documents which has not yet failed to provide us with the information which we need to find. Of course, this system is constantly undergoing change and improvement; and this constitutes another major part of our workload.

In reviewing and sorting all this information there was one need which became apparent to us; namely, a dictionary type document listing, and defining, all unclassified electronic test equipments which have been received nomenclature assignments. The simplicity of this document, SETE 210/38, is exceeded only by the use to which it has been put, and the demand into which it has come. At the moment we are working on a companion document which will contain a listing of the status of preferred items of electronic test equipment. If all goes well this document will be available in June of this year.

Having thus described some of the things we have done in the past and some of our present activities, I think you might be interested in some of my observations at this time.

First of all, I believe that your program here at the Depot. which is directed at evaluating some of the automatic test systems, is commendable. To my knowledge this is the only program of its type under way in this country today. The Army and Navy, as well as the Air Force, are extremely active in developing automatic test equipment for operational systems. But I repeat that the Air Force supports the only activity in this area that applies to Depot type support equipment, and has been doing so for at least two years. The Army Signal Corps has just started to embark on a program which might have similar objects in mind.

From my point of view, it should be unnecessary to sell automatic test equipment to this group. This equipment is not scheduled for the 1970's or 1980's, it is here today. The operational support equipment on the B-58 system comprises many tape programmed automatic testing devices. It is possible today

to requisition a tape just as one would requisition a technical order. It seems clear that automatic test equipment is here, and that more of it is coming, despite some of its disadvantages. The needs that will arise in connection with these developments should be anticipated. The program here at the Depot should help substantially in this regard. Furthermore, I believe the effort at the Depot should be in some way gaged to the magnitude of the effort on the operational systems.

A singular observation is that the complaint, so frequently heard five years ago, that nobody knows what is going on in test equipment and that nobody knows where to go to find out what is going on in this field, is no longer valid. Although there are many gaps in our information, it is true nevertheless, that Project SETE is a place where an exhaustive amount of technical information resides. This situation is substantially different from what existed five years ago. But now what do we find? In my opinion the information thus accumulated is not being used effectively. One gets the impression that the previously expressed complaints of not knowing what is going on or what is available was more of an excuse than a legitimate criticism being expressed in the hope of obtaining relief. I find that in too large a number of cases when contractor personnel visit our project it is with the primary intention of finding out about proposals, new contracts, new programs, etc. As I see it, the desire of the contractors representatives is not often enough in the direction of obtaining technical information in order to improve his project or his performance.

I believe that this situation would be remedied, and for that reason I will conclude my remarks with two recommendations: First, I think each of you here today,

and those of your colleagues with whom you have influence, should arrange to visit with us, or at least to communicate with us, before you start a new research and development program in the field of electronic test, checkout, and support equipment. You would also do well to follow this simple procedure with a new product improvement program. You have nothing to lose and everything to gain by considering this contact as the first step in such undertakings. Our purpose in inviting you to make use of the information we have is very simple. We may be able to provide information to you which otherwise you might come upon only by accident. It is to assist you in forming the best judgement of which you are capable in this area.

It is not our intention to belittle a program, or to tag it as being an undesirable duplication of effort. It is not our intention to thwart your progress. I can state one experience which, though small, is indicative of the support which our project can supply to you. A recent visitor decided to check with us before he embarked on a program in automatic test equipment. Although he had long and continued experience in this field, he nevertheless thought he would investigate what we had before he started his program. To his satisfaction, he found that 90% of the programs he knew about we know about, and that 90% of the programs which we knew about he knew about. The 10% which he supplied to us was very useful and appreciated, and the 10% of information which we supplied to him was equally well received. It was his observation, and a correct one, that even if we had supplied him with nothing new, the visit would have been worthwhile in that he would have felt more secure in the knowledge that the program in which he was getting involved was proper.

My second recommendation is that after you have started a program, and regardless of whether you have contacted us in its preparation or not, that you advise your contractor who has been awarded the program to visit with us at an early date so that his engineering personnel may obtain information which might otherwise be a long time in coming to him, if it came at all. Thank you.

END

AUTOMATIC TEST EQUIPMENT EVALUATION

L. E. HULDEMAN
Service Engineering Division
Dayton Air Force Depot

The subject of my talk is "Evaluation of ATE". As you already know, the Automatic Test Equipment Program was initiated in July 1958 by Hq USAF, through Hq AMC. The responsibility of establishing and monitoring the engineering portion of this program was assigned to the Service Engineering Division of the Directorate of Materiel Management at DAAFD. As you have been told earlier, the following objectives were established:

a. To investigate the feasibility of utilizing ATE for depot-level testing of prime electronic equipment, and to determine the extent to which such application is economically practicable within the AMC logistics system.

b. To integrate an ATE test and check-out capability with advanced Electronic Data Processing Equipment (EDPE) concepts to reduce maintenance to only those manual operations directed by ATE and by the EDPE Program.

c. To determine the requirements for universal, versatile, and flexible ATE incorporating building-block design concepts and plug-in module techniques.

d. To advance the state-of-the-art of ATE hardware with the ultimate goal of obtaining equipment for utilization on an Air Force-wide basis to test and check out electronic, electro-mechanical, hydraulic, pneumatic, and mechanical systems.

My talk will concern itself with the following phases of this program: DAAFD accomplishments to date; the current DAAFD program and objectives; an evaluation of the importance and necessity of ATE to the Air Force today; and a dissertation on some of our future objectives. This latter subject -- our future objectives -- is an infringement upon the subject to be covered by Colonel Riggs in his closing summation this afternoon. I feel, however, that I can be exonerated of guilt in this case because of the fact that our engineering investigations and evaluations on this program have brought to light the dire need and importance of emphasis in this area of ATE development.

Our initial engineering efforts were devoted to an investigation of the extent to which we could accomplish malfunction isolation, considering the limitations of test point accessibility in the prime equipment. We soon discovered that the inaccessibility of test points prevented us from determining the condition of many components. Much time and considerable effort was expended in the design and fabrication of adapters to partially overcome this difficulty. In the case of the AN/ARC-27 Airborne Radio Communications Equipment, we concentrated considerable engineering effort on the design of test fixtures, cables, and adapters which we used to test subassemblies, such as the guard receiver, spectrum amplifier, and the IF and audio amplifier. We gained valuable experience in this phase of the program.

Another area in which we have gained considerable knowledge and experience is that of programming. This is the process of writing detailed test instructions from the technical order (TO) covering the equipment to be tested, and then translating them into coded instructions on punched tape for the ATE. Many refinements and changes were made in the sequence of tests, tolerances or limits on measurements, and the number and extent of required tests. Programming is a skill which requires experience before proficiency can be gained.

Now let's summarize the accomplishments of DAAFD to date. At the outset of the ATE Program, it was decided to conduct evaluation studies on specific equipments, namely the Nortronics' "DATICO", the Lavoie "Robotester", the California Technical Industries "Supertester", and the Hickok "Cardamatic" Tube Checker. After discussion and investigation, it was agreed that we would program all dynamic tests on the DATICO, and utilize either the Robotester or the Supertester for static tests. This decision was based on the philosophy of taking full advantage of the limited capability, greater speed, and much lower cost of the Robotester or Supertester and utilizing the comparatively expensive

DATICO for tests beyond the capability of the Robotester or Supertester. It was necessary to make a choice between the two, so we performed comparative tests and chose the Robotester because of its better stability and capability of giving more consistent test results. These engineering evaluation studies have been completed and it has been conclusively proven that the utilization of ATE for depot-level testing is not only feasible and practical, but is economically advantageous.

Practical application of ATE has been successfully demonstrated on two separate occasions at Davis-Monthan AFB in Tucson, Arizona. The first time DATICO was employed from 13 February to 17 March 1960 to segregate serviceable AN/ARC-27 Airborne Radio Communications equipment from sets of unknown operating condition which had been removed from salvage aircraft. During this application the program tape for DATICO was refined in order to obtain the desired segregation in the shortest possible time. Tests having the highest failure rate or frequency of occurrence were programmed first in the test sequence. Out of 810 units tested, 309 units were determined to be serviceable, and were returned to the Air Force inventory. This total was 38.1% of the 810 RT-178/ARC-27's tested, and represented a savings of 90% in man-hours and equipment when compared to the present manual test methods. During this application of ATE, the DATICO alone exhibited a mean-time-to-failure of 22.9 hours. At this point, I feel that an explanation should be given of how we arrived at the value of mean-time-to-failure (commonly referred to as MTBF). This figure was calculated by dividing the total number of operating hours by the total number of failures which occurred. The Service Unit, used in conjunction with the DATICO, proved to have an MTBF of 14.1 hours, and the MTBF of the combined system was 8.75 hours. Here I have just used another term, "Service Unit", which I will define. By "Service Unit" I mean the unit which includes the stimuli generator, D-C power supplies, and the R-F power converter. The second application covered the period between 18 July

and 30 September 1960. Again, the purpose was the same-to segregate serviceable equipment from sets of unknown quality. In this project, a total of 1173 RT-279/APX-6A and -25 Airborne Radar Identification units were tested. Of this number, a total of 396 units were found to be in serviceable condition. This represented 33.8% of the total quantity checked, and again a savings of 90% in man-hours and equipment was realized through the use of ATE. In comparison, the results of the second project show a marked improvement in mean-time-to-failure of the ATE equipment over the first such application. The MTBF of the DATICO alone was 51 hours, representing an increase of 123% over the first project. The Service Unit displayed an MTBF of 57.5 hours, which was 308% better than the previous trial, and the combined ATE system exhibited an MTBF of 27.06 hours, which was 209% over the first application.

This comparison is definite proof of the forward progress which has been made in ATE technology. The ARC-27 Service Unit was very inferior to the APX Service Unit. The APX Service Unit yielded an increase of over 300% in mean-time-to-failure compared to the ARC-27 Service Unit. The DATICO's used for both operations were basically of the same design.

You are undobtedly wondering about the cost of the ATE equipment used during the Tucson operations which I have just summarized. Actually,the equipment has more than paid for itself on these two programs alone. This fact can be confirmed and verified by actual figures covering the initial cost of the ATE system, the cost of operation, and the savings realized from the recovery of serviceable equipment, with consideration being given to the cost of similar tests if they had been performed manually.

The same ATE equipment is presently being utilized in a pilot-shop operation at DAAFD. This phase of the current program was recently launched to determine the feasibility of using ATE on a production basis for test and checkout of AN/ARC-27 equipment. Approximately

1000 R-T units which were removed from salvage aircraft will be checked, using methods similar to those used at Davis-Monthan AFB.

We are also conducting three study programs on a contract basis-one by ARINC Research Corporation, one by Stromberg-Carlson, and a third by Nortronics.

The objective of the study being performed under contract by ARINC is to determine the effect on field reliability resulting from the utilization of ATE, in comparison to that achieved with the present manual shop methods. This study is being conducted at Lockbourne AFB, Columbus, Ohio under actual operating conditions in tactical aircraft. The test vehicle being used is the ARC-27 equipment. One half of the total quantity of equipments involved in this project will be tested solely with ATE, and the other half will be tested exclusively by manual methods. Early results already indicate that a definite improvement in field reliability can be expected as a result of the use of ATE. Based on 4% of the test data which will be obtained, the ATE segment has displayed an MTBF of approximately 60 hours, whereas the manual segment has given an MTBF of approximately 40 hours. We hope to prove conclusively by results from this study that a very definite and appreciable improvement in reliability can be obtained at lower cost through the substitution of ATE for manual testing methods. This phase of our program will be discussed in greater detail by Mr. Frank Ruther in his talk on "Reliability Study."

The study program being performed on contract by Stromberg-Carlson will define the requirements for signal generators, transducers, switching, etc. which will be necessary to provide the ATE testing capability which we are striving to achieve. This study will also result in a comparison of costs and manpower requirements for both manual and ATE methods, and make recommendations of the type of ATE which is best-suited to perform depot-level testing. This study will be discussed in greater detail by Mr. Richard Stimson in is talk on "Feasibility Study."

The study being conducted by Nortronics under contract is aimed at determining the feasibility of utilizing computer techniques in conjunction with ATE and will recommend possible applications in which computer techniques can be advantageously utilized. I will expand upon this phase of our current program later on when I discuss the "Air Force Depot Equipment Performance Tester" study program (referred to as "ADEPT").

I have previously mentioned two terms-namely, "building-block" and "plug-in module." For the benefit of those who are not familiar with this terminology, I will give an explanation of the intended meaning.

The first term, "building-block", describes an engineering design concept which makes it possible to achieve maximum testing capability with a minimum number of modules. Standardized modules of ATE equipment would be utilized, thereby eliminating unnecessary duplication of hardware. Here, in my reference to "modules", I am talking about such assemblies as the programmer, timer, comparator, and digital voltmeter. With this concept, it would be possible to select only those standard modules, or "building blocks," which would be required to accomplish any desired tests, and make it unnecessary to tie up equipment not required. These modules would then be assembled as "building-blocks" and interconnected for use. I do not mean to imply that all modules can be standardized. There will very definitely be requirements for families of stimulus generators, power supplies, pulse forming and shaping networks, modulation circuits, and special modules for peculiar applications. The number of modules which would be required to make up a so-called family would be determined by the range of test requirements and the limitations of engineering design capability. As the state-of-the-art of engineering design advanced, the size of a family would decrease. The complexity of the ATE hardware would be determined solely by the complexity of the testing requirement. In other words, we would be able to build up the capability of the ATE equipment only to the degree determined by the complexity of the

testing requirement. In contrast, the ATE equipment which we presently have in our Air Force inventory makes it necessary to use equipment which is far more expensive and sophisticated than that which is necessary to accomplish required testing. There is no ATE equipment in the inventory today which possesses intermediate capability.

The second term, "plug-in module," is used to describe removable subassemblies, such as stimulus generators and power supplies, which are connected into the circuitry of the ATE equipment by means of plug-in connectors, rather than by soldered connections. By this means we would be able to extend the range of a stimulus generator, or change the pulse characterics, by the simple expedient of removing one module and replacing it with another which has the desired capability. This technique is already used on some relays and transformers, and to a limited degree in present ATE hardware.

I may sound repetitious in my repeated references to these two terms-"building blocks" and "plug-in module", -however I firmly believe that their importance cannot be over-emphasized in relation to their necessity in keeping pace with the increasing complexity of electronic systems and the almost insurmountable workload which it entails.

We are presently in the embryonic stages of achieving the full benefits of ATE utilization. Automation is a process which cannot be accomplished overnight but instead requires a gradual changeover resulting from engineering studies and evaluation programs. In order to arrive at the best solution to the problem, it will be necessary to express the requirements of the Air Force in terms of test parameters, and define the hardware in terms of performance and detail specifications. This phase of the program will be covered later on in the program. Getting back to our position today, many people are perturbed about the equipment breakdowns and other obstacles which we have encountered. They expect miracles from ATE, and feel that we should have completed our task long ago. However, they would nly have to review development programs in other areas, such as radio or television,

to realize that many failures were experienced before the first working model was produced. Malfunctions, breakdowns, and failures are to be expected in the early stages of development, rather than cause alarm or create a pessimistic attitude when they occur. We have encountered many such disappointments, however, we cannot afford to look upon them as insurmountable roadblocks in our path toward achieving our ultimate objectives. We have analyzed and evaluated several possible methods of reaching the goals which we have established, but since we are dedicated to doing the job conscientiously and economically, we cannot select the easiest way out. To do so would require the needless expenditure of money which we can ill afford. The solution to the problem, as I stated previously, will require the development of the building-block concept and plug-in module technique in order to achieve maximum equipment versatility at minimum cost. Actually, this philosophy of approach is not as radical as it may sound, since approximately seventy to eighty percent of the circuitry presently used in ATE is common to most testing requirements. The major departure from present day production practices would be required in packaging techniques. This "building-block" approach has many advantages over our present-day state-of-the-art, from both technical and economic standpoints. The development costs required to achieve standardization of modules would be rapidly recovered through the savings made possible by greatly increased flexibility and versatility, and by the elimination of a large percentage of duplication of ATE equipment.

With the rapidly-increasing complexity of electronic systems and subsystems (which I cited previously), the importance of developing ATE which can provide the Air Force with the capability of carrying out its assigned maintenance mission is becoming more and more urgent. The value of ATE is emphasized by the fact that it can perform testing functions more consistently, thoroughly, rapidly, and accurately than can be performed by manual methods.

Our future program and long-range objectives will be covered later on this afternoon.

AUTOMATIC TEST EQUIPMENT PROGRESS REPORT

Frank J. Ruther
Chief, Service Engineering Division
Dayton Air Force Depot

ATE PROGRESS REPORT

by

FRANK J. RUTHER

Approximately two years ago in February, the DAAFD held an Automatic Test Equipment (ATE) Symposium. At that time we had just started into our engineering evaluation of the pieces of equipment that were available at the time. Since then we have expanded our evaluation to bring into play programmable tube testing equipment.

At that time we answered the question about ATE of what, why, and how much. We definitely can give a complete answer as to what it is, we can give most of the answer of why, and we are coming close to being able to answer the question, how much. We were fairly accurate in saying what it was two years ago, and I illustrated that by a little anecdote concerning a piece of equipment that had been designed and was ready to be tested. The test procedures were all laid out when the contractor called in an ATE company. And they asked this ATE company how they would do it. The reply was, "The same way only automatically." We have found in the two years that this statement "the same way only automatically" is all but too true.

Two years ago we listed six reasons why we should use ATE equipment and we explained each of these reasons. The six reasons were:

1. Less skill required.
2. Uniformity of testing.
3. The testing is done faster.
4. Higher quality of the turned-out repaired product.

5. Better logistic control.

6. Saves money.

Two years ago we said, 1. "Less skill required" was true, providing the tape program was prepared in the proper manner. This is an understatement of the age. The tape program preparation and stimuli are the biggest and most difficult problems facing the Air Force. Buying tapes from contractors appears to be the only way out but our methods of buying such tapes have not been worked out to the point where we can turn loose a contractor and get what we need in the Air Force. 2. "Uniform testing." This is definitely true, and even more true today than it was two years ago. Since the functions of the machine are determined by the holes punched on program tape or imprinted electrically on a magnetic tape it is impossible to automatically skip-test or to perform them in a haphazard manner. We have found that the tapes can be changed by operators and occasionally this has happened in our own shop operation. It is best that a program tape reproducer be in the shop but not a punch that can control individual holes. 3. "Faster." The actual machine speed is quite rapid in most available ATE's and we demonstrated this yesterday. However, it should be remembered that connecting adapters stimuli and inserting test plugs has to be done before the test can be performed. Therefore, this should be considered as part of the test time. Something in the order of 40 percent of the time utilized with ATE is spent in making these necessary connections. 4. "Higher quality." As Mr. Huldeman has told you and as you have heard from my

discussion of reliability this is true. And this seems to be the biggest reason for using ATE. We can include more tests, the tests are performed uniformly, in the same sequence, the equipment that is repaired, using total automatic testing as far as practical here at DAAFD, are staying in the air 50 percent longer without failure than those that were repaired using the normal means prior to ATE. 5. "Logistic control" can be greatly facilitated by using information printed on, or punched by the ATE read-out. We here at Gentile have definite indications that the present failure reporting system is only about 18 percent effective. 6. "Saves money." Until the design of equipment in the basic R & D phase considers test point accessibility the inaccessibility of test points will have a bad effect on cost. Whether or not money can be saved in the actual repair operation depends to a large extent on what value we can place on the higher quality. "This is a gray area where it appears we will have difficulty obtaining substantiating evidence in a short period of time." Two years ago we said this, today our program of measuring the quality or the reliability of items tested by automatic testing means, is giving us sufficient knowledge to actually know where we are going from here.

OVERALL GOALS

The overall goal of the engineering evaluation is to acquire the know-how in sufficient detail to automate that portion of the Air Force testing job that should be automated.

In order to accomplish this goal plans and time-phased steps are necessary. The inter-relationship of time, money, manpower,

and the state-of-the-art forces a certain amount of realism in these plans. Two years ago when I spoke to this group I purposely left out time and I am thankful I did. This time around we will discuss time.

1. By July 1961 we will have comparative cost figures for automating the depot versus continuing on manual test basis. This will include the accumulated relationship of:

a. Manpower needs for each method.

b. Interchangeability of stimuli and transducers.

c. Cost of automating.

(1) Old and new equipment.

(2) Limiting the automation to only new equipment entering the inventory. For example, the ARC-68 and others coming down the road after that.

2. Reliability versus maintenance cost curve.

a. By Aug 61 we will have two points on this curve established.

b. By Dec 61 we will have sufficient points on the curve to define the total picture.

3. The above will give and has given economic justification for automating the maintenance testing load. We have planning PR's into Procurement to buy engineering service for developing programs, designing of adapters, and in general adding hands and minds to our engineering and technical staff, to speed the automating process. The long range goal is 70 percent automation by Jan 64 with the gradual build up as an outgrowth of the model shop operation going on at the present.

4. In order not to confine the Air Force to one system of ATE we have written the necessary work statement to have developed an automatic means of converting program tapes from one system of ATE to another. This is similar to the same type of work that was accomplished with regard to EDPE. This work will be accomplished during the next 9 month period and I must repeat that this must be successful or ATE will die due to political pressure. "We cannot do a program as comprehensive and as broad as this on a sole-source basis."

FEASIBILITY STUDY OF AUTOMATIC TEST EQUIPMENT APPLICATION

Richard A. Stimson
Service Engineering Division
Dayton Air Force Depot

FEASIBILITY STUDY OF ATE APPLICATION

by

RICHARD A. STIMSON

Can Automatic Test Equipment (ATE) be made versatile? DAAFD engineers and engineers of Stromberg-Carlson, on a contract awarded by the depot, are making a nine month study to determine versatile stimuli, measurement, and adapter characteristics of ATE. This study was initiated to determine defective module and part isolation test requirements of a representative cross section of depot inventory items. This data was to define ATE stimuli and measurement functions, ranges, and accuracies. Prime equipment physical characteristics, such as test point accessibility and modular or subassembly breakdown were also studied to determine test point connection and test fixture requirements.

The study was conducted by making a detailed analysis of 15 representative depot inventory items, including communications, IFF, ECM and radar equipments repaired in our maintenance shop.

The first step in the study was to derive a basic maintenance philosophy. It was determined that defective black boxes, as they are received, would be checked dynamically and statically on ATE to isolate defective modules. The defective modules could then be replaced by good modules, the black box retested, and if passing satisfactorily returned to the serviceable inventory. The defective modules would then be further tested, both statically and dynamically, to isolate defective components.

I have used three words, module, static testing, and dynamic testing, which may not be clear to all of you. In this case, modules are subassemblies which can be removed from the black boxes. Static testing is the testing of values such as continuity, resistance, inductance, and impedance. Dynamic testing is the testing of circuits under operating conditions.

After the basic maintenance concept was derived the next step was to review all existing technical literature such as government Technical Manuals, and manufacuters data. Then the circuit schematics and the physical black boxes were studied and analyzed to determine the theoretical tests necessary to isolate the various defective components in the black boxes and in the modules.

After the theoretical tests were derived it was next determined whether it was physically possible to make these tests. Typical questions to be answered were:

1. points available?
2. can tube sockets be used?
3. can one component be isolated from another?

The next step was to then determine the stimulus generators and the response monitors including their ranges and accuracies. A good example of a stimulus generator would be a signal generator; a response monitor would be a vacuum tube voltmeter or an oscilloscope.

After determination of the test points, their accessibility, and the response monitors and stimulus generators, all the test data could then be assembled.

This was done in 17 categories, such as RF generator, DC power supply, frequency meter, and DC voltmeter requirements. A series of graphical plots for each category was made. A typical graph plots the number of black box test requirements versus frequency of RF stimulus generators. Companion graphs show accuracies required and frequency coverage required for prime equipment types.

The test data was also recorded on IBM cards. Machine sorting can be applied to assemble all test data by prime equipment types or by stimulus generator or measurement unit types or by frequency or voltage sub-divisions within a stimulus generator type. While IBM card processing was not absolutely necessary for 15 equipments, the format developed is useful for any study of broader scope.

Finally, comparisons were made between costs of the manual test equipment now used and that of ATE defined in the study and of testing costs using manual and proposed ATE methods.

I have not mentioned reliability or the fact that more defective parts are found with ATE than is found with the manual method. This will be discussed by other speakers.

As a result of this present contract there were a few other factors that we desired. Therefore, an extension to the contract is being negotiated. This extension is to make studies in more detail on certain parts of the basic study. This will include design requirements for ATE, which are not now presently available. Also, the basic study determined the feasibility for the ultimate use of ATE in our maintenance shop. Needed next are some of the stepping stones necessary along the way.

The equipment study, graphical presentation, cost and data analysis have led to several significant results. First, all 15 equipments can definitely be tested by ATE for both system performance and defective part isolation to a small subassembly or a small number of components. The degree of defective component isolation possible using conventional ATE measurement techniques is a function of circuit design, packaging and number of test points utilized.

The greatest number of tests needed for fault isolation to a defective module was found to be thirteen hundred (1300) for a doppler radar navigational computer. For a typical transmitter-receiver, from 100 to 485 tests are required to determine a faulty module or subassembly.

To go the next step further, that is, to determine a defective component or isolate to a small number of components within a defective module or subassembly, the number of tests required ranges from 6 to 225, depending on the module complexity.

The graphical data presentations have indicated logical overall ranges and characteristics of building block units within a power supply or signal generator orpulse generator family. They have also indicated the programming resolution required, assuming digitally programmed units will be used.

In summary, the present study program has determined specific test requirements of typical Air Force inventory equipment, defined the ATE peripheral equipment required, and analyzed present manual and proposed ATE costs. By full utilization of these results and further study of the related aspects of programming and definition

of the complete ATE complex, an overall plan to economically implement ATE at DAAFD will evolve.

What will all of this do for you? First, you will have a knowledge of ATE electrical requirements which are feasible. There will be available in the study report the techniques needed to make similar studies of specific equipment. It will list the procedures to follow, the types of data to collect, and the type of personnel necessary to make studies.

Foremost, however, is that we feel confident that versatility of ATE is feasible. This concept and the studies that we have made well provide the nucleus for further application of ATE to other equipments throughout the Air Force.

MENEX
(MAINTENANCE ENGINEERING EXCHANGE)

MR. JAMES W. GRODSKY
OFFICE OF SECRETARY OF DEFENSE

PRESENTATION BY JAMES W. GRODSKY
AT THE
AUTOMATIC TEST EQUIPMENT SYMPOSIUM
HELD AT DAAFD 10-11 JAN 1961

Mr. Chairman and fellow participants: I appreciate the opportunity to say a few words at this Symposium. I thought that you might be interested in a program that we have sponsored at the Department of Defense. We call this program "MENEX", which means Maintenance Engineering Exchange. The program was started with the idea of assuring that available reports in the field of maintenance engineering and maintainability are made known to those organizations and individuals who need this information. In the MENEX Program, the Office of Maintenance Engineering, ODDR&E, acts as the focal point, receiving information on maintenance engineering and maintainability reports prepared by industry and government organizations and distributing this information as a semi-annual bulletin directly to industry and government.

On September 7, 1960, the Office of Maintenance Engineering forwarded a letter announcing the MENEX Program to approximately 800 industrial personnel and to the Assistant Secretaries of the Army, Navy and Air Force (R&D) for transmittal to Military Service organizations. In this letter we requested that information on reports concerning maintenance engineering and maintainability be submitted to our office. These reports have been reviewed and their titles, abstracts and pertinent reference information have been listed in the MENEX Bulletin. This bulletin will be published twice a year and will be mailed directly to personnel interested in receiving it.

You may ask where we are in this program. The initial announcement letter was mailed in Sept. 1960. As of this date approximately 200 individuals have indicated a desire to participate in the program. A date of December 1960 was set as a goal for publication of the first MENEX Bulletin. This has slipped slightly; we now plan to distribute the bulletin on Jan. 19, 1961. The first bulletin will contain information on a small number of reports received through the MENEX Program plus a large number of reports which have been accumulated by ASTIA from 1953 to date. The bulletin will be unclassified; however, it will include reference to a bibliography of classified ASTIA reports on the subject. We plan to issue the second bulletin in July 1961.

If anyone here at the Symposium would like to participate in the MENEX Program, please let us know by letter, postcard, phone or any other means. We will be pleased to have you. I would like to emphasize that this program is a two way street and that traffic must flow in both directions for the

program to be successful. We will send the MENEX Bulletin to people who indicate that they need it. In order for the Bulletin to be useful, it must contain complete and current information - we depend upon the program participants to send us this information. We will keep the traffic moving from us to you; be sure that you keep the traffic moving from you to us. If you would like to participate in the MENEX Program please let us know at this address:

Office of Maintenance Engineering
Office of the Director of Defense Research and Engineering
Washington 25, D. C.

A TRANSCRIPT
AUTOMATIC TEST EQUIPMENT

BY

MR. JOHN R. TAYLOR
OFFICE OF SECRETARY OF DEFENSE

TRANSCRIPT BY JOHN R. TAYLOR
OFFICE OF SECRETARY OF DEFENSE
WASHINGTON 25, D. C.

Mr. Chairman and Fellow Participants in the Automatic Test Equipment Symposium:

I have some personal beliefs and concepts about Automatic Test Equipment that you may be interested in. These concern both the present and the future. It is quite apparent to me that automatic test equipment is destined to play an important role in future advances in technology.

It has only been a few years ago that maintenance of any automatic electronic systems, such as fire control, navigation, etc., was nearly impossible due to lack of ability to diagnose malfunctioning. The many interactions and relationships established in this new equipment were beyond human ability to assimilate with the equipment on hand. At this point, our ability as a nation to take advantage of new advanced technology was to be tested. Happily, we met the test. Automatic test equipment was the answer, and as we progress in the future the application of highly automated devices will depend, by and large, on such test equipment.

Where are we today? To me, we have followed a natural course. Having the ability now to design and develop automatic test equipment, we have turned our attention to the design of new automated weapons systems and devices, with little thought given to the mounting use and application of automatic test equipment. The situation is that we have no standard ATE and therefore are not able to specify the use of such equipment in the development of new weapons systems. Consequently, we are forced to buy tailored test equipment from the

prime contractor to support his new weapons. This in turn is building up to a major problem in the not too distant future in that we will be faced with hundreds of millions of dollars worth of obsolescent test equipment.

The key to the present and future of ATE is to find an optimum design philosophy that can be standardized on a DOD-wide basis, and in turn be specified for use with new weapons and systems in the development stage. Such equipment must include those characteristics that provide: maximum flexibility of use and application; expansion to accept new test measurements as they are required and developed; simplification of maintenance and modification; and competitiveness in procurement. Until we achieve this we will continue in the vicious cycle of developing for each new weapon new tailored test equipment. The redundant engineering created by this situation is a gross waste of such talent and an expense that we can reasonably avoid.

It is my belief that the answer to a design philosophy for automatic test equipment lies in the building block concept. Each test function performed is measured to a standard. A family of standards built to a given range and level of accuracy could become the building blocks. They would be designed to a standard size for use with a standard racking. These standards would then be used with a standardized programmer/comparator such as the GJQ/9. Here we have a design philosophy that provides for the essential characteristics. A system of this kind could be specified for use with new weapons, and this is what must be done if we are to break the current cycle.

From what Colonel Riggs has been telling us here today, I am satisfied that we are headed in the right direction. In general, most people concerned with this business recognize the same problems. We in DOD are aware of your problems and are planning to create a group to study appropriate means of solution. The work you are doing here should be of considerable benefit to such a group.

I wish to extend my thanks and appreciation to Colonel Veal, Colonel Riggs, and Mr. Kyle for an eventful day. I personally feel I have gained much from this symposium. Certainly, it has helped to substantiate certain of my beliefs. The tests being performed here and the data being compiled should give concrete evidence of the way to proceed.

I have enjoyed meeting with many of the participants and invite you to visit my office in Washington should the occasion present itself. Thank you.

D A F D A T E S Y M P O S I U M

10 - 11 JAN 61

PROGRESS REPORT ON DATICO EQUIPMENT INSTALLED IN DME AT MAAMA

Presented By:

Mr. L. B. Ratcliff
D/MM, MANMPP
Ext. 2217

Datico, the Digital Automatic Tape Intelligence Checkout Equipment manufactured by Nortronics, Anaheim, California was delivered to MAAMA in June 1959. This equipment was originally procured to introduce automated testing capabilities for various Type B-6 Autopilot Amplifiers. In addition, it was planned that this equipment would be periodically revised by the addition of new auxiliary modules and programming so as to become a Universal Amplifier Check-out test facility to replace the specialized Test Sets used to inspect and trouble-shoot the many different types of amplifiers and electronic control packages used in airborne autopilot, guidance, and navigation systems.

Datico was designed to achieve this degree of flexibility by being composed of two main units: (1) The main control and measurement console composed of tape reader, programmer, compositor, timer, counter, control relays, Digital Multimeter, and program patchboard. (2) The service unit which contains signal generators and voltage dividing networks, pneumatic supply - to supply input signals to the B-6 amplifier under test. This machine has a good measure of success with the B-6 amplifiers. Because of its speed it can perform an incoming troubleshooting inspection in approximately 0.25 hours and a final inspection on an amplifier in 0.75 hours, whereas the former manual pre and final inspection took about 7.4 hours. Because of systematic programming and printout of all measurements fault isolation led to pinpointing defective circuits, the reduction of test time was 4.5 hours. The repair operations for the average repair cycle fell from 17.9 hours down to about 13.4 hours. In addition the measurement accuracy and exact repeat of measurement methods ruled out the human factors that lend to marginal units passing or failing inspection.

It is to be realized that instrument workloads fluctuate from month to month and from year to year. In order to get the most value out of expensive equipment, it must be at work all the time processing whatever instrument that happens to be ready for test. It should be able to change from one test to another in a couple of minutes by plugging in new cables, slipping in new patchboards and clamping on a different spool of perforated tape.

A project was therefore launched to select three new amplifiers and program Datico to perform the necessary troubleshooting and inspection. The A-12D Autopilot Amplifier, N-1 Compass Amplifier, and J-4 Compass Servo-Amplifier were selected. The A-12D was selected because 3/4 of its circuits were identical to those of the B-6, the difference being the substitution of a Bank angle limiter circuit for the Compass Amplifier of the B-6. It was felt that the same equipment in the service unit plus very few additional networks would do the job of supplying simulated input signals. The N-1 was selected because it contained types of servo power amplifiers. The J-4 was chosen because of its wide spread use on many different aircraft both as the primary navigation system of fighters and backup compass on bombers. Its existance in the Air Force is anticipated for many years to come.

Before starting any programming work we had to know how the system works. The Air Force contracted with Nortronics to present a six-week training course to 32 men selected from the various components at Middletown. Equipment Specialists, Engineers, and Mechanics learned the detailed functions of the various modules, the program code, programming techniques and the equipment in the B-6 service unit.

The next step was a try at programming the A-12D by two Engineers from the Service Engineering Division. The result of this study was the realization that a drawer full of transformers, relays, and voltage dividing networks would be necessary just to supply simulated input signals for the bank angle limiter. This study took about 8 weeks and was cpmplicated by the way that standard Overhaul Technical Orders are written. In order to compose instructions for Datico to perform a test sequence you must specify what voltages you need to apply and at what points and what signal you want to measure and at what pin. The Technical Orders on the other hand are written for the operator applicable to a particular test set. The test sequence usually calls out the positioning of a series of switches on the panel and you read the measurement on a panel meter. The translations involves weeks of tracing of the circuit diagrams of the test set.

A contract was then procured with Nortronics for a feasibility study, in detail, for the N-1, J-4, and A-12-D Amplifiers. This study was to develop the program and service unit equipment requirements, as well as finding the feasibility of programming 17 new components. Nortronics sent two applications engineers to MAAMA Shops. They sat down with two instrument technicians and two technicians from Industrial Engineering for 10 weeks tracing circuits and writing commands. Eight weeks later Nortronics published an Engineering Report and Preliminary Model Specification. The report stated quite correctly that much new service equipment is required, not only to simulate input signals, but to measure output signals. The cost for engineering the additional gear, including program tapes for three amplifiers was approximately $167,000. Because of the expense of programming old instruments from standard T.O.'s the view point of expanding the application of automatic testing to instrument overhaul may be difficult for amplifier type testing in relation to time and expense.

ADDITIONAL FLIGHT INSTRUMENTS SURVEYED

A. GENERAL

Twenty-five additional instruments were surveyed to test the applicability of automatic checkout procedures to these units. The instruments investigated were gyros, servoamplifiers, indicators, and servomechanisms.

B. GYROS

The displacement gyros can not be fully tested with the present service unit. This type of testing requires a computer, torquer amplifier, Scorsby table, and displacement tables. Equipment such as this will be used for gyros only. Time is another factor to be considered, gyros require long time periods for test. The checkout equipment would be tied up for long periods of time. During the bulk of this time, the computer and DATICO would be inactive. For these reasons the following instruments were rejected:

(1) Directional Slaved Control Gyro
P/N 15810-1

(2) Directional Slaving Control Gyro
P/N 15150-1

(3) Directional Stabilized Control Gyro
P/N 421156-1

(4) Vertical Control Gyro
P/N 421155-1

(5) Directional Control Gyro
P/N 423040-2

(6) Vertical Speed Altitude Indicator
P/N 18001-2A-2-A1

(7) Mach Safe Speed Air Speed Indicator
P/N 18000-1A-1-A1

(8) Compass Controller
P/N 131312-01

(9) Displacement Gyroscope Assembly
P/N 129370-01

C. TRANSDUCERS

Three transducers were surveyed but were rejected for automatic checkout because of specialized service equipment required and long time periods required for system stabilization.

(1) Engine Pressure Ratio Transmitter
P/N 24094-4 Air Research

(2) Engine Pressure Ratio Transducer
P/N LG 14A1 Minneapolis-Honeywell

(3) Temperature Synchro Signal Amplifier
P/N 8KE55AAb1, General Electric

D. SERVOAMPLIFIERS

Several other instruments were surveyed and found to be applicable to automatic testing and within the capability of the service unit.

(1) Accessory Servoamplifier
P/N 23170-00-001

(2) Altitude-Azimuth Computer Servoamplifier
P/N B24200-00-001

(3) Astro-Tracker Servoamplifier
P/N B24220-00-002

(4) Correction Computer Servoamplifier
P/N B24210-00-001

(5) Erection Amplifier
P/N B24670-00-002

(6) Altitude Director Indicator
P/N 131314-01

(7) Amplifier Power Supply
P/N 131313-01

(8) Aircraft Flight Director Computer
P/N CPU-4/A

(9) Horizontal Situation Indicator Group
P/N AF/A24J-1

(10) Compass Adapter
P/N 131316-01

(11) Altitude-Vertical Speed Amplifier
P/N 15461-1-A-1

(12) Rate Gyroscope Transmitter
P/N 131311-01

(13) Mach Number Safe Speed Airspeed Amplifier
P/N 15462-1-A-1

An evaluation of the present prospect of automatic test equipment for aircraft instrumentation as applicable at MAAMA. The basic concept of automatic testing is sound and all claims regarding time and accuracy can be substantiated, however, the situation at MAAMA is showing complications wherein we are becoming the victims of competition in individual automatic test equipment. Once the automation picture was accepted, every manufacturer hopped on the band wagon and established his own methods and standards of performance. This, in addition to the absence of any such specifications in the Air Force, presents a situation for the service which will result in considerable confusion, and each new facet examined exhibits more of the same.

The overall picture at this writing is:

1. MAAMA has a DATICO unit suited to the B-6 Amplifier only and capable of a printed read-out.

2. MAAMA has contracted for a Super Tester unit for use with the MD-1 Astro Tracker, NOT capable of a printed read-out.

3. AF has contracted for automatic testers from Bendix for use with the automatic flight control system of the B-58. They are the 13935 Amplifier-Computer Tester and the 13936 Power Control Linkage Assembly Tester. Neither is capable of printed read-out.

4. ASC at AMC has contracted with Kearfott for 3 automatic testers for use with the AN/AJN-8 Navigation Systems. They are capable of printing.

This means MAAMA will have seven different automatic testers from four different manufacturers with no interchangeability factor without the expenditure of considerable funds. The reference to printing stems from requirements of quality and inspection who presently use the printed tapes from these machines. Without them their manhours and the machines time will double, thus off-setting any saving made in another phase of operation.

The logical place to introduce this concept is in the design of new instrument systems; to start with a machine that has wide parameters and have the instrument manufacturer design his product to be tested on an Air Force one standard test machine. The manufacturer will only sell the Air Force the program sequence and an adaptor module. One of the major problems is; who knows what characteristics are in the electronic equipment of the future and what sort of service unit will fulfill all of the requirements?

PRODUCTION ON B-6, -1 and -6 AMPLIFIERS AT MAAMA

	PRE-CHECK	O.K. ON PRE-CHECK	FINAL CHECK
SEPTEMBER - 1959			14
OCTOBER - 1959			115
NOVEMBER - 1959			40
DECEMBER - 1959	79	19	72
JANUARY - 1960	111	26	114
FEBRUARY - 1960	147	27	161
MARCH - 1960	38	6	103
APRIL - 1960	92	6	138
MAY - 1960	101	13	141
JUNE - 1960	65	3	90
JULY - 1960	This month Digital Multimeter was returned to factory for repairs.		
AUGUST - 1960	117	24	95
SEPTEMBER - 1960	42	7	65
OCTOBER - 1960	146	33	161
NOVEMBER - 1960	75	26	84
DECEMBER - 1960	128	33	150
	1141	223	1543

ATCH # 1

MAAMA DATICO OPERATING TIME vs DOWN TIME

	OPER TIME	DOWN TIME	
OCTOBER 1959	334	29	
NOVEMBER 1959	126	114	(Stepping Switchs)
DECEMBER 1959	145	63	(Stepping Switchs)
JANUARY 1960	267	34.5	
FEBRUARY 1960	224	38.8	
MARCH 1960	170	43.0	
APRIL 1960	230	26.8	
MAY 1960	233	16.6	
JUNE 1960	172	114	(DMM OUT)
JULY 1960	0	136	(DMM OUT)
AUGUST 1960	180	115	(DMM OUT)
SEPTEMBER 1960	206	0	
OCTOBER 1960	220	7	
NOVEMBER 1960	210	1	
DECEMBER 1960	166	9	
TOTAL TIME	2883	732.4	
FACTOR	80%	20%	

ATCH # 2

AN EVALUATION OF ITEMS COVERED IN FEASIBILITY STUDY

RELATIVE TO DATICO APPLICATION, BASED ON WORKLOAD

AND MACHINE UTILIZATION

ITEM NR	NOUN	MFG PART #	FED #	REQMTS FY 62
1	Accessory Servo Amplifier	C23170-00-001	6605-593-5324	**28
2	Altitude-Azimuth Computer Servo Amp	B24200-00-001	6605-593-5319	**14
3	Astro-Tracker Servo Amplifier	B24220-00-002	6605-675-2213	**34
4	Correction Computer Servo Amplifier	B24210-00-001	6605-593-5320	**38
5	Erection Amplifier	B24670-00-002	6605-658-2563	**24
6	Altitude Direction Indicator	131314-01	6610-633-4283	*364
7	Amplifier Power Supply	131313-01	6615-632-3628	**33
8	Aircraft Flight Direction Computer	CPU-4/A 5221279003	6610-633-4258	*221
9	Horizonal Situation Indicator Group	AF/A24J-1 5221393003	6610-633-4260	*279
10	Compass Adapter	131316-01	6615-632-3630	*265
11	Altitude-Vertical Speed Amp.	15461-1-A-1	6610-633-4314	**47
12	Rate Gyroscope Transmitter	131311-01	6610-633-4282	*211
13	Mach Number Safe Speed Airspeed Amp	15462-1-A-1	6610-633-4315	**47
14	N-1 Compass Amplifier	16000	6605-501-2370	259
15	J-4 Compass Amplifier	423060-3	6605-556-9318	851
16	A-12D Autopilot Amplifier	608816-1	6615-341-9863	**63
17	A-12D Autopilot Amplifier	608816-2	6615-348-0567	739
18	B-6 (Being O/H at MAAMA)		6615-518-4702	205
19	B-6 (Being O/H at MAAMA)		6615-518-4709	900

* Workload not firm as of this date. This quantity is Air Force wide requirements.

** Quantity does not justify.

ATCH # 3

OPERATIONAL

	EI STD	PRE-TEST	FINAL TEST	ASSUR TEST	INSP TEST	C/N
6.	18.75	1.18	.50	.34	.50	32748
8.	18.63	2.43	.75	.35	.75	32719
9.	23.90	4.37	1.01	.35	1.01	32718
10.	17.72	1.50	1.60		1.60	32746
12.	1.50	.25	.25		.25	32747
14.	7.50	1.00	1.30		1.30	30067
15.	8.70	.50	.50		.50	32189
17.	18.39	1.00	2.75		2.75	31784
16.*		1.00	2.75		2.75	31725

* Similar to item #17

ATCH # 4

ESTIMATED TEST TIMES

	TOTAL # OF E/I		EACH MANUAL TIME	TOTAL MANUAL TIME	EACH DATICO TIME	TOTAL DATICO TIME	TOTAL M/H SAVINGS
6.	364	x	2.52	917.28	.75	273.00	644.28
8.	221	x	4.28	945.88	1.00	221.00	724.88
9.	279	x	6.74	1880.46	1.25	348.75	1531.70
10.	265	x	4.70	1245.50	1.00	265.00	980.50
12.	211	x	.75	158.25	.20	42.20	*116.05
14.	259	x	3.60	932.40	.75	194.25	738.15
15.	851	x	1.50	1267.50	.50	425.50	482.00
17.	739	x	5.50	4064.50	1.00	739.00	4057.11
18.**	205	x	5.50	1127.50	1.00	205.00	1125.45
19.**	900	x	5.50	4950.00	1.00	900.00	4050.00
16.	63	x	5.50	346.50	1.00	63.00	283.50
	4357			17,835.77		3,676.70	14,159.07
12.				-158.25		-42.20	-116.05
TOTAL				17,677.52		3,634.50	14,043.02

* MH Savings does not warrant programming. Not included in total.

	Total Manual Time	Total DATICO Time	Total M/H Savings
** Presently on DATICO	-6,077.50	-1,105.00	-5,175.45
Proposed	11,600.02	2,529.50	8,867.57

ATCH # 5

ESTIMATE OF DATICO MANHOUR SAVINGS - FY 62

INCLUDING ITEMS BEING PROGRAMMED BY MAAMA.

	MANUAL TEST TIME	DATICO TEST MANUAL	METHOD TIMES ON DATICO	SAVING MANHOURS EACH	FY 62 QTY	TOTAL FY 62 MANHOUR SAVINGS
On Datico						
6615-518-4702	*7.40	1.80	1.10	4.50	205	922
6615-518-4709	*7.40	1.80	1.10	4.50	900	4,150
SUB-TOTAL						5,072
Proposed						
6605-487-4769	.94		.30	.64	1,464	936
6615-605-8489	4.50	1.50	1.00	2.00	611	1,222
6615-341-9863	*7.40	2.60	1.10	3.70	63)	
6615-348-0567	*7.40	2.60	1.10	3.70	739)	4,776
6615-568-4676	*7.40	2.60	1.10	3.70	489)	
SUB-TOTAL						6,934
TOTAL						12,006

* In process tests included for these items.

NOTE: Test times include production tests and inspection tests.

ATCH # 6

TEST AUTOMATION FOR AIRCRAFT AND MISSILES
(PROJECT ACE)

MR. SIDNEY I. FIRSTMAN
RAND CORPORATION
SANTA MONICA, CALIFORNIA

In the years since World War II there has been a revolution in military technology. As you well know, one mark of this revolution has been the rise of the operational--and budgetary--importance of the complex ground support equipment for modern weapon systems. At the same time, there have been increased demands for skilled maintenance technicians, who were already in short supply. Many weapon systems, such as Atlas and Titan, require high speeds for their operational checkouts; others such as Minuteman require checkout operations and measurements which unmanned equipment must perform rapidly, remotely, and precisely. Thus, in many systems, increasingly difficult and complex problems have superseded the somewhat easier diagnostic and repair problems of a few years back.

It became apparent to those of you who were watching from the viewpoint of operations and maintenance, that automatic test and checkout equipment would be the answer to many--but not all--of the problems posed. Automatically controlled equipment can perform some kinds of tests with much more rapidity, precision, and repeatability than are possible with manual techniques. Moreover, such equipment can work unattended in remote sites.

This same automation possibility also became apparent to the weapon system and electronics contractors, and I understand that by mid-1958 ARDC had received a staggering number of proposals for automatic test and checkout equipment. These proposals were for equipments that would do jobs automatically; jobs that ranged from simply testing the continuity of wires to performing diagnostic tests on complete missiles or aircraft, and then order whatever parts are needed, post the weapon status at an appropriate headquarters, and perhaps even wake up the crew chief, the commanding officer, or CINCSAC, whoever was appropriate. (And I've exaggerated only slightly on the last point.)

It was at this time, late in 1958, that RAND was asked by Generals Anderson and Mills to look at this matter of test and checkout automation, and in my talk to you today, I would like to acquaint you with some of the things that we have done on this broad set of problems. We call our study Project ACE--for Automatic Checkout Equipment.

By way of introduction to my later comments, I want to bring attention to several categorical statements made by ACE (automatic checkout equipment) manufacturers, or hopeful manufacturers, about such automatic equipment. Statements like these are the essence of many of the proposals received by ARDC, and perhaps you would like our reactions to them. Some of these statements we believe have merit, and others we have reason to disbelieve. First, the statements, or claims, that appear to have merit.

It is claimed that ACE can take a design engineer's logic and test methods and place them in use at every installation they are needed the world over, by means of the program prepared for the automatic equipment. This statement is true, to the extent that the automatic equipment can be programmed in a manner paralleling the test logic employed by the engineer, and has been proved by automatic checkout equipment presently in the field. On the other hand, some checkout equipment cannot be programmed to perform the exact tests performed manually, and must therefore either use substitute automatic tests, or revert to the manual methods; this happens frequently. We are also finding that not all needed tests can be anticipated, and this causes a continued dependence on a skilled technician. Some important design issues left unanswered in this area of test design are what tests should be done during, say, the ground life of a missile and during pre-launch checkout, what test efficiencies are required, and what types of equipment are best used for these tests. Our project has looked at these problems and we have some results that I'll show you in a few minutes.

A second claim that appears to have merit is that the tests performed by ACE have the desirable attribute of repeatability. A test, once programmed, will be performed in the same manner, using the same inputs and limits of acceptability, wherever and whenever they are performed. This assertion too appears correct to the extent that the individual checkout systems are operating properly and were properly designed in the first place. Unfortunately some equipment has not met these provisos.

At this point I should probably pose the usual questions of "who checks out the checkout equipment?" and "where does the chain of test equipment end?" For the older--I could say first generation--equipments, these were and are real problems. Fortunately, though, newer--or second generation--equipments are incorporating self test capabilities, so that these checkout equipments, by and large, check themselves.

A third claim often proffered to credit ACE is that test result data can be accumulated without human effort or possible human error, and that these data can be made available in a form that is readily useful for logistic and command functions. If enough money is spent to provide data output equipment for the ACE, this assertion too is apparently correct. Two important issues that are often left unresolved, however, are what types of data should the ACE generate, and how much is this automatically generated data worth in terms of both dollars of equipment or manual functions replaced?

We are presently looking into the data implications of these automatic equipments; let me expand a bit and tell you a little about our activity and some of our preliminary attitudes. To begin with, we must recognize that ACE is not a system unto itself. It cannot be regarded as an independent piece of hardware or as a total system. People who build or propose to build ACE often forget that the data output requirements placed on ACE must be viewed in terms of its relationship to the larger Air Force information structure. Thus, ACE must be viewed in light of its role as a data originator and in

terms of its relationship to the total Air Force management information system. In this sense, ACE is a subsystem in the total Air Force information system, which consists of the command and control subsystem, the supply subsystem, the maintenance subsystem, the personnel subsystem, etc. It is our preliminary thesis that the information output of ACE is dependent on the demands of these subsystems and must be integrated with them. In particular, ACE can supply key data for weapon system command and control, supply, and maintenance. If it is to do this effectively, the data output must be compatible--not competitive--with existing information systems. This also means, of course, that the kind of data supplied by ACE must be directly useful in terms of information content and compatible in form with the other data systems, such as punched cards or punched tape. This compatibility can be achieved only if proper attention is paid to data requirements early enough during the equipment's design.

The level of data detail must be carefully planned. It is axiomatic that the kind and amount of data furnished by ACE should be no greater than required by the control and support systems. In this context, though, let's observe that the same automatic test equipment could be used at several echelons for test and maintenance (e.g., site, squadron, depot); each echelon could require a different level of data detail. Hence, we may need to compromise a basic design or we must provide for different types of data output for each basic checkout system.

In particular we are starting to look at the relationship of potential ACE output to existing or planned automatic control or support systems--like 465L and IOC-2. In our present examination of the roles that ACE could play in the Air Force data systems, we hope to develop a conceptual framework for decisions on the preferred data generating and processing activities of ACE. As I mentioned while ACE could generate many kinds of data, not all of them are warranted.

To return to the topic of manufacturers' claims, on the negative side of the ledger are two assertions that are often made, but are unfounded for many applications. The first of these is that ACE saves dollars; the second is that ACE saves manpower and lowers the skill requirements. We all know that it's difficult to say anything general about this matter of dollar savings, and therefore any sweeping claims should be eyed with skepticism. For most weapon systems automation of some test and maintenance functions can do either--save dollars or cost more dollars. As for other applications of automation, savings will result only if the equipment utilization is high, and this utilization will depend completely on the particulars of the equipment speed and capacity and the operations of the organization that is to use it.

We are presently looking at several manpower issues, and I'll have more to say about this later. For the moment, though, let me pass on an interesting finding that we are looking into. Two study groups have found that automating test functions will certainly not decrease the skill requirements for the maintenance technician, and may in certain cases increase them; this is contrary to the claim of many proposals for automatic equipment. Unless we are to depend completely on an automatic testing device, which is unlikely, and because some required tests cannot be anticipated, especially during the early life of a weapon system, the operator must know how to do manual diagnoses and repair of the weapon. In addition he must be able to operate and perhaps repair the automatic tester. Hence, increased demands for the technician's skills.

EXPOSITORY PAPER ON ACE

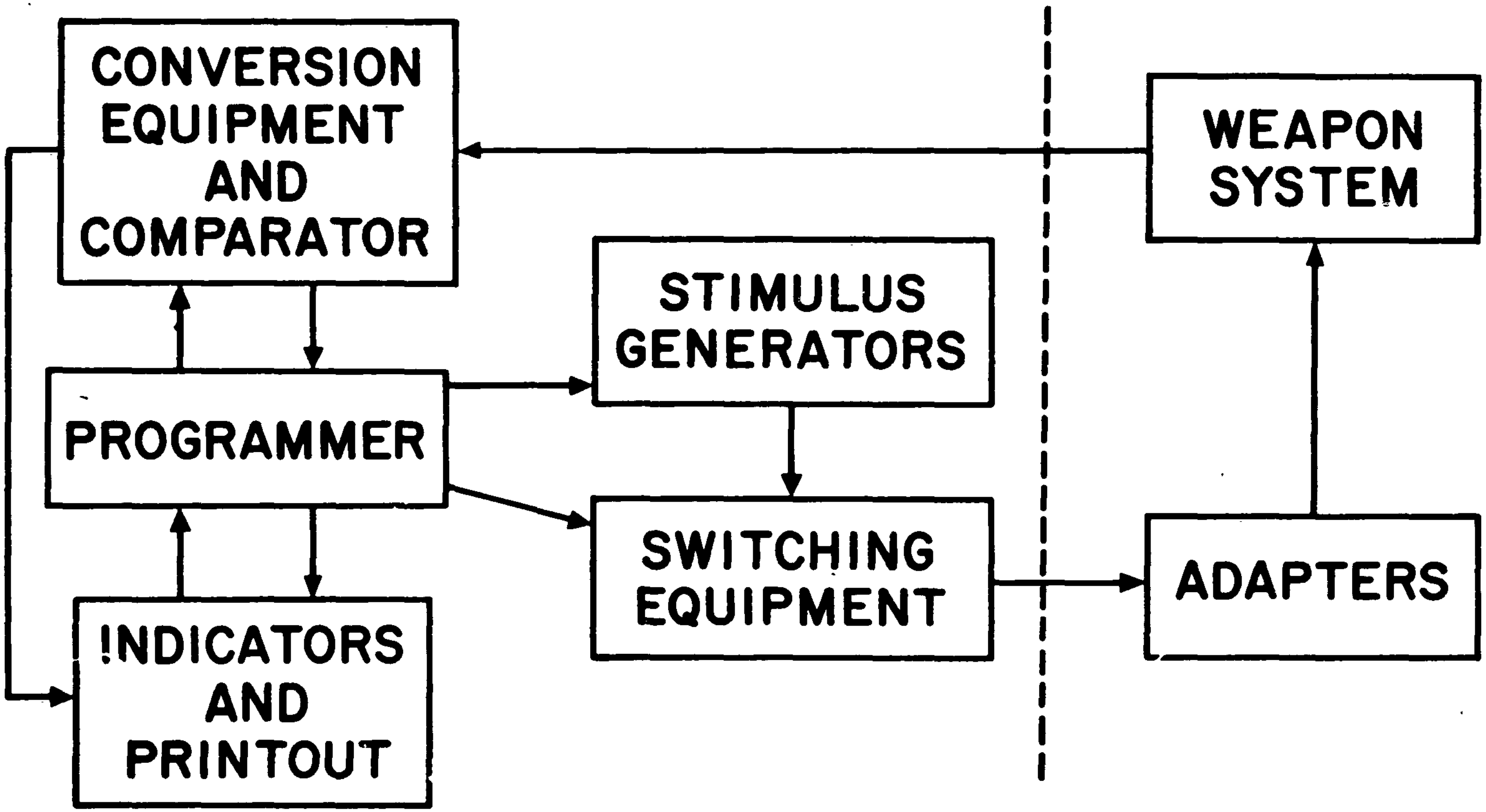
I'm now going to move on to our Project ACE--what we have accomplished to date, and a little more on plans for continued study. The first thing we observed when looking at this broad problem area is that the Air Force is spending many millions of dollars on automatic test and checkout equipment, of one sort or another, and as yet there was no unified objective treatment of the subject available to the Air Force. By this I mean that there was no single reference that one could go to that presented a broad range of ACE design and employment possibilities. After extending our education in this field, we sat down to write such a reference.

As an example of the issues we address in this, what we call, "primer" on ACE, let's examine this sketch (Chart 1) of an idealized automatic checkout system--some people call this a "universal" type of system.

This checkout system encompasses the means for performing the general test functions of control, stimulus generation, response measurement, and decision making. The programmer controls the checkout equipment; let's observe that it is this device that makes this system different from a manual test system. The stimulus generators supply the required inputs or test signals. These signals are routed through the switching equipment and the adapters to the system under test. The conversion equipment converts analog response signals from the system under test into a form usable for evaluation and display. The comparator essentially measures the response and compares it with a predetermined reference. The indicators change the measurement information to a form suitable for decision making by humans. This information is also fed back to the programmer, which serves as the automatic decision element.

Chart 1

TYPICAL AUTOMATIC CHECKOUT SYSTEM



Let's focus our attention on the programmer for a moment; a section of the report is devoted to it. The programmer contains the store of necessary test logic, instructions, and limits, and controls the test equipment and system under test according to its store of knowledge. It is sometimes called the "brains" of the checkout equipment.

For manual or semi-automatic systems, the programmer is the technician. For automatic systems, this programmer can be built about a paper tape reader, as is done in the AN/GJQ-9, which is the first of an Air Force series of "universal" programmers; it can use punched cards, as is done by the APCHE equipment used with Atlas; or it can employ a digital computer; the Army has several efforts underway to further explore this possibility. Each of these programmer types has a different capability for test control, and for different test situations one or the other would be preferred technically; their costs however could be significantly different. Often, though, a contractor who seeks to sell a digital computer for test control, which in general is the most expensive of the programmers, may argue for the expensive device largely on the basis of its <u>speed of test</u> capability.

This speed capability is not always significant, and must be considered within the over-all test environment. In the Report, for this comparison of programmer speeds, we devoted several pages to show how to address three relevant questions: <u>first</u>, how fast can information be supplied by the different types of programmers--computers are certainly faster than tapes--<u>second</u>, what is the contribution of fast information flow to the speed of the complete test sequence--some test operations could require 10-20 seconds, and this dwarfs a programming time savings of fractions of seconds--<u>third</u>, in the over-all test sequence context, is the cost of increased programmer speed justified--sometimes even the most expensive device would be justified

if it alone could do the job in the time allowed by the anticipated operational context.

OPERATIONAL DESIGN CRITERIA

Let's move on to another study area of Project ACE, that of developing objective operational design criteria for these automatic systems. And let's confine our attention to automatic test and checkout equipment that operates with ballistic missiles. Criteria for the design of a missile's ground system are of several natures. At present, typical criteria will state conditions like, "electronic equipment must be capable of unattended operation for a period of 60 days," "electronic and hydraulic equipments will be designed capable of being maintained using a remove and replace concept," or "standard test equipment will be employed wherever possible." In conjunction with these criteria for the physical requirements of the equipment, statements derived from objective studies are needed to specify what the equipment is to do, how well it must do these tests, how often, and so forth. These are operational design criteria; they are rules for the use of the equipment, and goals or guides for the design of the equipment. In the past, precious little objective attention has been given to such criteria. Instead, they have been set by the methods of "rule of thumb" and "engineering judgment."

Parts of a missile (missile functions) perform physical roles--they propel the missile, they guide the missile, etc. In addition, these functions play operational roles--they must operate as a unit to accomplish a mission, and because missile hardware is not perfect, i.e., it demonstrates failure characteristics, it necessitates certain ground operations. Readiness testing is one of these ground operations that is made necessary by missile unreliability, and its effectiveness is measured in operational terms.

Readiness Testing

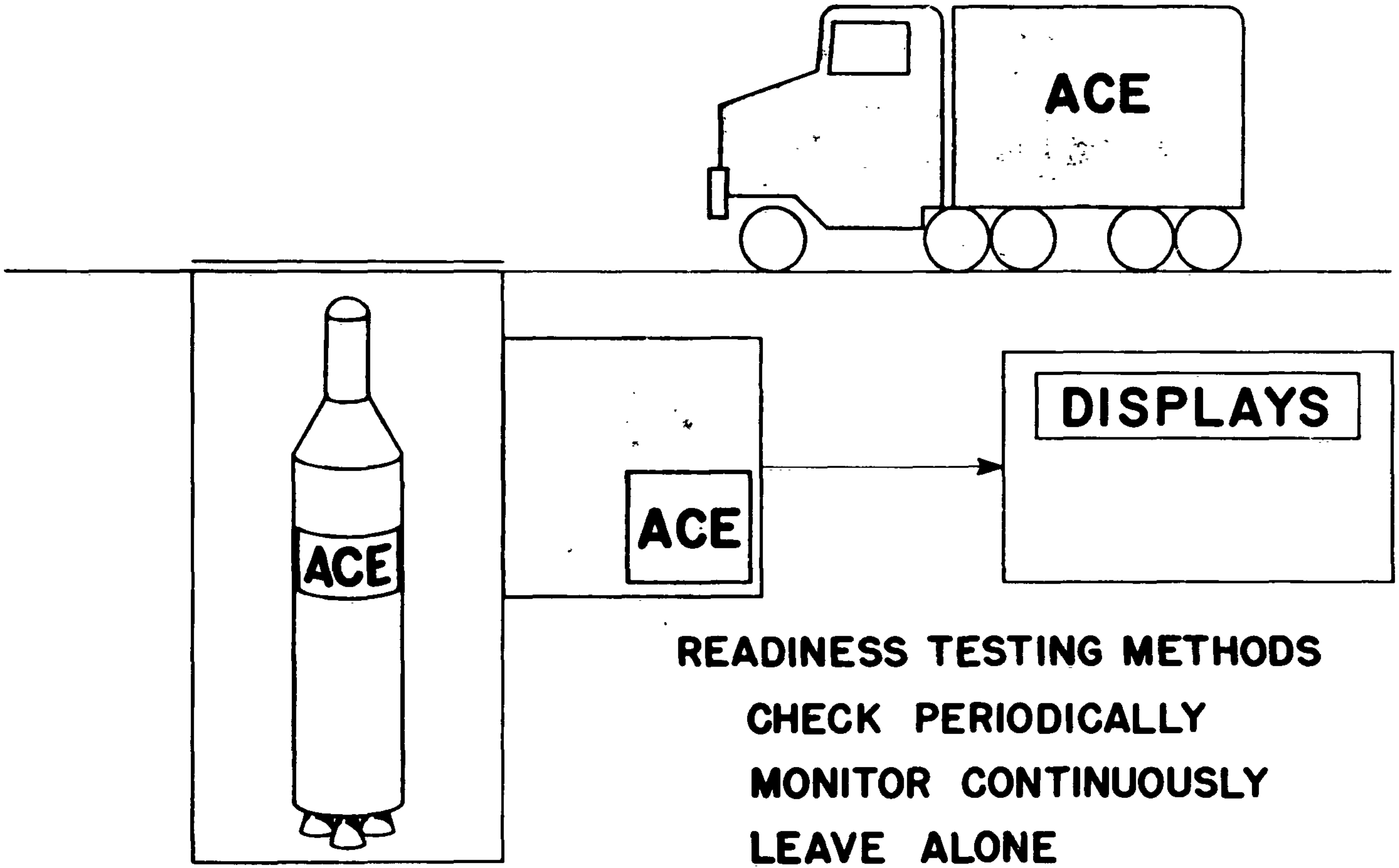
Readiness testing is that set of tests performed regularly for the dual purposes of helping to keep the missile in a launch-ready condition, and keeping the commander informed on the status of the missiles in his force. I've already discussed some of the data implications of ACE. Let me show you two of our results in this area of readiness testing for maintenance purposes; the first result will be concerned with determining a system concept for testing; the second result will be directed toward designing the test methods and equipment within the system concept.

A missile emplaced in a silo is tested in several ways, using equipment in several locations. (See Chart 2) For safety and physical reasons some functions on the missile are monitored continuously; two examples are propellant or oxidizer tank pressure and gyro fluid temperature. Other functions are essentially left alone for extended periods of time; solid propellant engines are a case in point. Some functions, and indeed the major portion for most missiles, are checked periodically. They are checked because failures do occur while a missile is in a static mode, and, these failures should be detected and repaired before a launch attempt is to be made.

For those functions that are checked periodically, the best testing intervals must be determined, i.e., how often should the tests be performed--weekly, monthly, yearly...? When determining a system test concept, the system cost and capability are the prime considerations. For example, there are costs associated with taking a van of equipment out to a missile site to test the missile. There are other costs associated with repairing a missile that contains a malfunction--perhaps one that is caused by testing. On the other hand, a missile that contains a malfunction that has not been

Chart 2

LOCATION OF TEST EQUIPMENT



READINESS TESTING METHODS

CHECK PERIODICALLY

MONITOR CONTINUOUSLY

LEAVE ALONE

detected is probably more detrimental to the force than one that is down for maintenance, as we would be erroneously planning on its use. These failures can be detected only by testing.

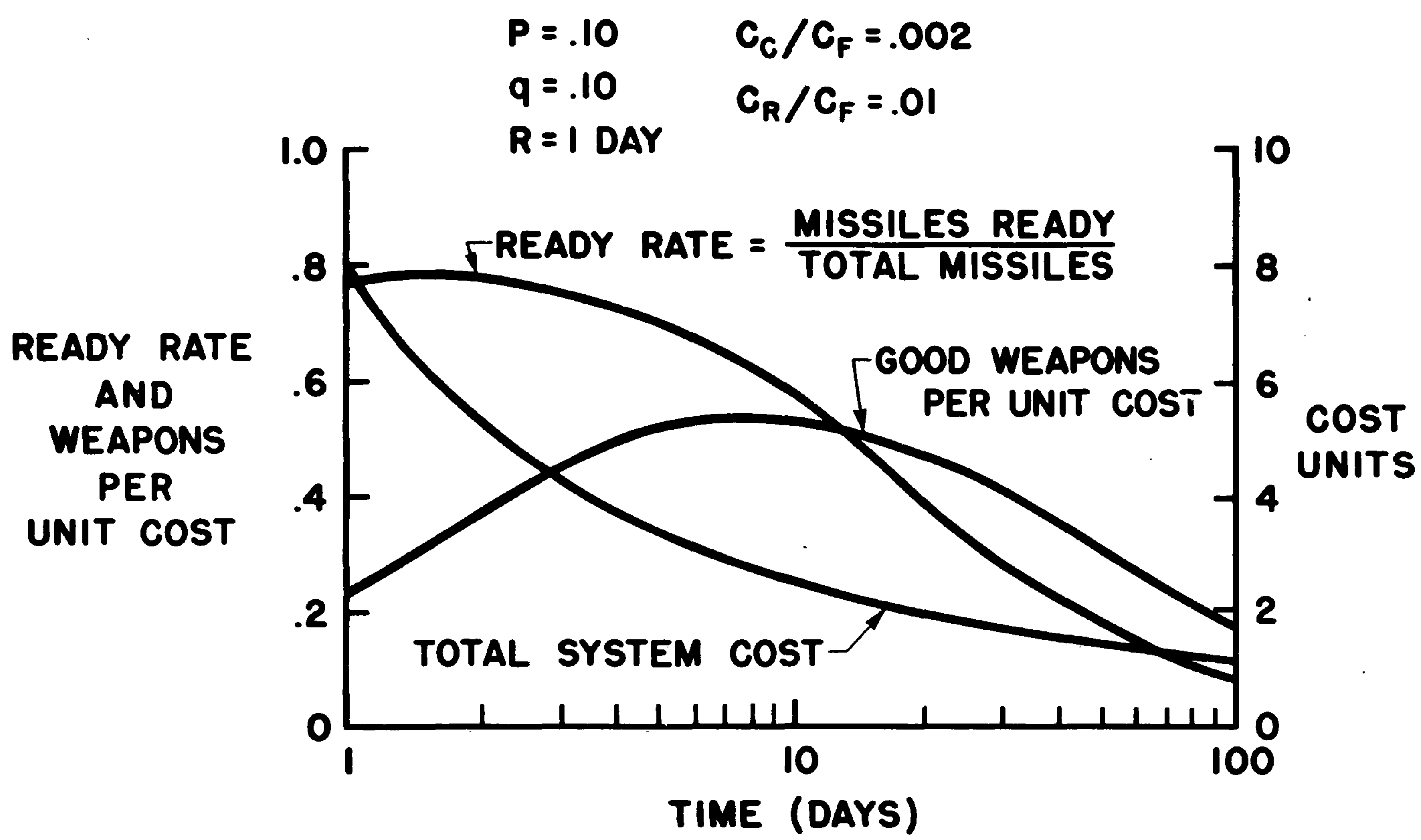
Looking at these testing costs, and the costs of missile and test equipment procurement and installation, and at the sources of missile downtime, one can ask, what is the minimum frequency of testing that will assure a given capability, i.e., a given number of ready missiles, for the least dollars spent on the entire system. Or, he could ask, within a fixed budget and with all other system parameters being held constant, how often should the missiles be tested to assure that the greatest number are ready to go at all times?

Both of these problems can be answered in the same way. When the total weapon system cost for a given force size, basing concept, and so forth, is factored into those costs associated with testing and repair and all other costs, it can be plotted as on this chart (Chart 3). Here we show the total weapon system cost as a function of the checkout period for a hypothetical missile system. Notice that for this example, as the period of test changes from one day to 100 days, the weapon system cost decreases drastically.

On the other hand, by stretching out the time between periodics, we are allowing more missiles to remain in their silos with undetected failures. These missiles are not ready to go--even though a squadron status board would indicate that they are ready. This problem is shown on the second curve on this chart, which shows how the ready rate, or the ratio of missiles ready to the total number of missiles, changes with the test period. Notice that for very small test intervals the ready rate decreases, and this is because we are spending too much time testing and this testing is causing

Chart 3

PERIODIC TEST SCHEDULING



failures that must be repaired. We can observe from these curves that the best capability is achieved at almost the highest cost. Therefore we must examine the trade-off between cost and capability, and determine the best compromise. The system criterion of effectiveness, that works for both the fixed budget and fixed capability cases I described, is ready rate per system dollar. Finding the best ready rate per system dollar is equivalent to finding the test frequency that maximizes the total number of missiles that are ready to go per dollar spent on the system. This best test frequency is obtained by simply dividing the number of ready missiles for each test frequency by the associated total system cost, and the results are shown on the third curve on the chart. It is the number of good weapons per unit cost, and it shows that in this hypothetical case the best test period is about 10 days. If the missiles are tested every 10 days, the system will demonstrate its best readiness capability.

This approach, or method, was concerned with those functions of a missile that are checked periodically, and it was based on cost and operational factors that are of necessity gross and descriptive of large elements of a missile. We feel the method is useful for helping determine system testing concepts because it provides a convenient objective framework for examining numerous important support trade-offs.

This approach to periodic test scheduling was concerned with developing one element of a system concept. Once the entire system-design-and-operation concept has been determined, the test equipment must be designed to operate within the concept. One important question for the equipment designer is, for those missile functions for which design freedom exists, how does one decide whether to check it periodically, or to monitor it continuously (if this is possible), or, perhaps, to leave it alone until a launch attempt is

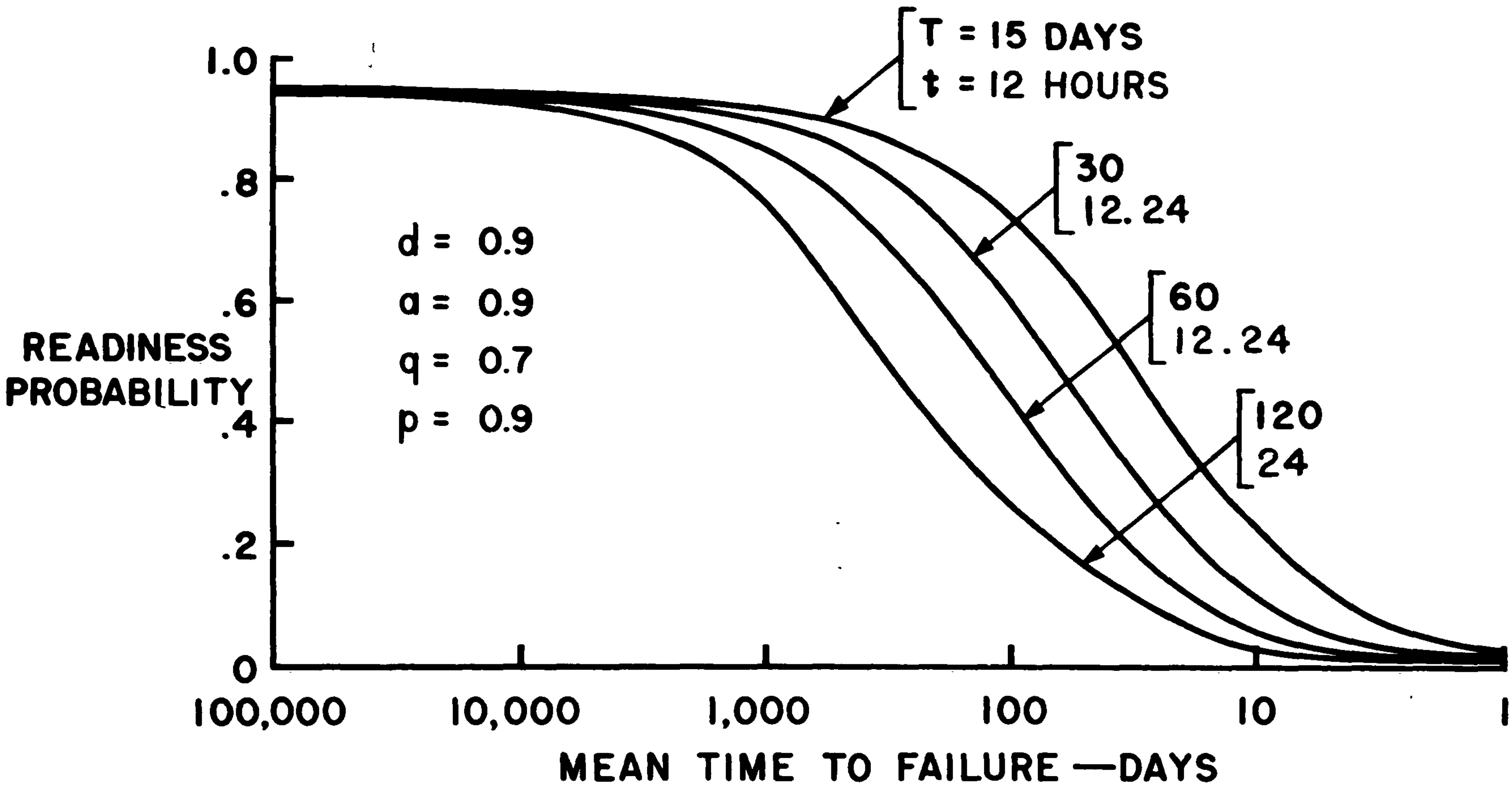
to be made? Answers to these questions determine the nature of the test equipment to be employed within the system concept. We are presently developing a method to aid engineers in such design decisions. I'll not go through our progress on this method in detail now because it would take too much time, but let me show you one interesting portion.

Briefly, the readiness testing equipment design problem we are addressing is this (see chart 2). Test equipment can be located in a van, in the silo, or aboard the missile. For some systems this van might give place to a helicopter. The test equipment in all three places could be used to check periodically, while the silo and missile equipment could also be used to monitor continuously. Because of their different capabilities to detect failures, the timeliness of their detections, and their varying propensities toward causing failures, each testing method will give a different readiness for each missile function. We like to measure this readiness by the probability that the function will be operative at any randomly chosen future time, e.g., the time when the missile must be launched.

Because these readiness probabilities differ from method to method for a particular function, the problem is to choose the method and equipment location combination that is best for each function. As a first step, we parametrically described these readiness probability terms for all combinations of missile function and testing method characteristics. Here is a plot (chart 4) of one set of probabilities; these are for check-periodically mode of testing. We can see that these descriptions are based on such factors as the function reliability, expressed in mean-time-to-failure under ground conditions, the test equipment access and accuracy which give the p and q estimates, the test period T, obtained from the previous method, the chance of causing a failure by testing d,

Chart 4

CHECK PERIODICALLY



and a measure of the maintenance concept a, i.e., an accounting for planned delays in repairing a known failure. For these particular curves, the time to repair a malfunctioned part, t, was included in the analysis, but its impact on the results was found to be insignificant. In essence, these curves tell you that if you test a function having these characteristics (reliability, d), using test equipment with these characteristics (p, q), according to a concept with these characteristics (a, t, T), then this readiness will result.

From these sorts of curves we can get the readiness probability for each function on the missile for each combination of method and equipment location. To use these numbers, we have laid out a design tableau--which we are now trying out on a hypothetical missile. On this tableau the numbers are entered for each function, or group of functions, and each test equipment location and method. Tests that are constrained by physical or safety reasons are indicated, and then the balance of the test program is chosen by finding the method--location combination that is best for each function. If complete design freedom exists, then this process will yield the theoretically best readiness-testing program, consistent with the system concept.

It could happen, however, that one or all of the possible locations could be space or weight limited, and then compromises must be made. We have devised a way to help make these compromise decisions too; once again using a design tableau.

Prelaunch Checkout

Let's move on now from those tests performed regularly to those performed immediately prior to launching a missile. The last, and perhaps the most important, task that test equipment must do for a missile is to

conduct a pre-launch confidence checkout as part of the countdown. We can observe that, in general, it makes good sense to keep all missile functions ready as much of the time as is feasible. This does not mean however that all functions will be kept 100% ready. Furthermore, it appears to be a poor policy to depend on the pre-launch checkout to detect existing faults in a missile, because this either creates a need for an increased wartime maintenance capability, or the missile will not be launched. In combination, these observations argue to (a) make the readiness testing as good as possible, and (b) develop the pre-launch checkout program to complement the readiness testing--using the outputs of the readiness-testing analysis as inputs to the pre-launch checkout analysis.

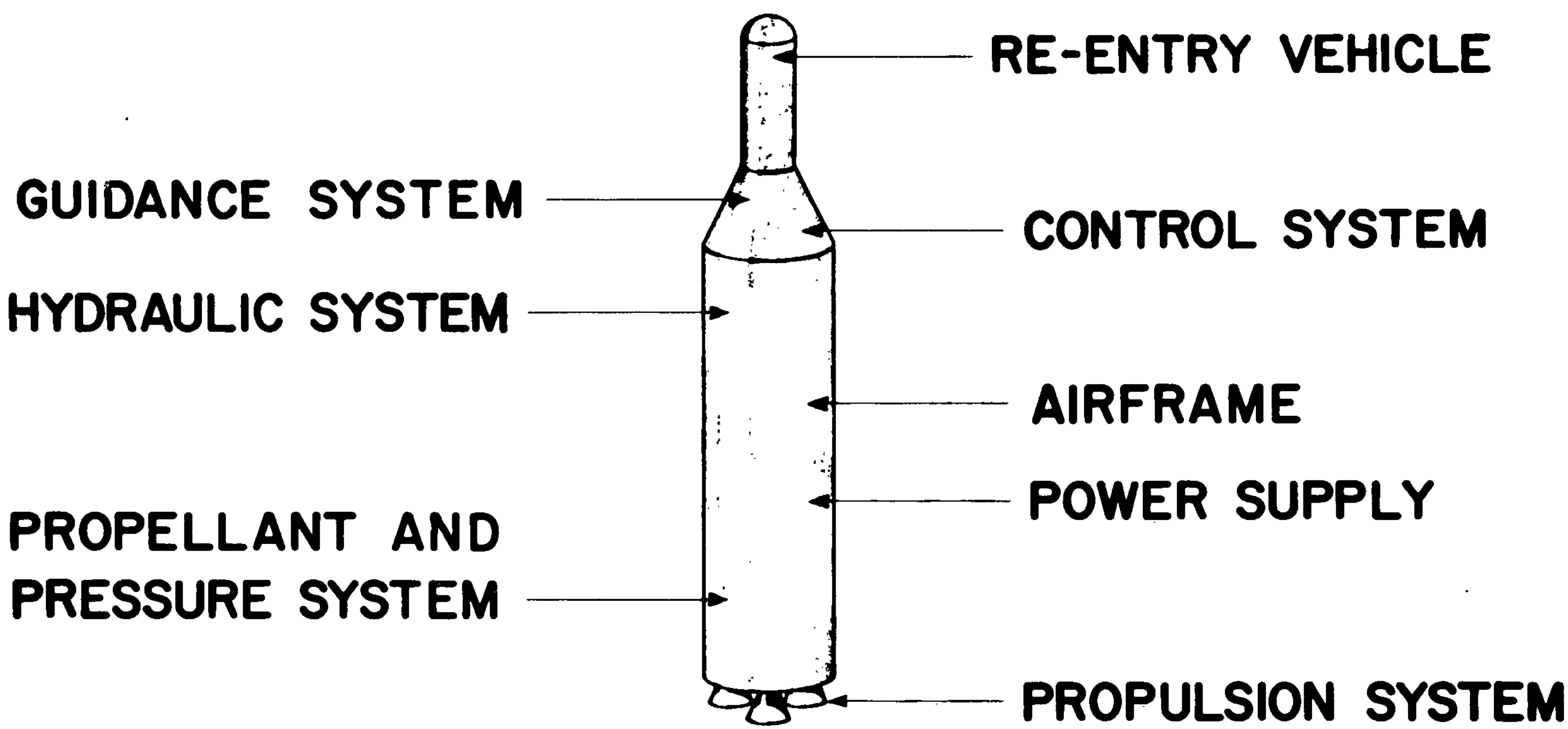
In talking with several of the ballistic missile contractors, we inquired as to how the pre-launch checkout is designed. How are the tests chosen that will be performed in the limited time available for such tests? It turns out that the typical procedure is to hold a meeting of those concerned, and the checkout that results is a compromise of their judgment and intuition.

We want to develop objective design criteria that could be used as a point of departure for such design decisions and thereby lessen this dependence on judgment and intuition. We were able to develop a technique that uses the operational requirements on the missile as a basic design criterion and gives the theoretically best checkout and the required efficiency of the test equipment. Let me develop the problem briefly, and show you the resulting technique.

Here's a typical ballistic missile (chart 5). It has a propulsion system, a guidance system, and so forth. Each of these is a potential candidate for checking during the pre-launch checkout, because each could

Chart 5

HYPOTHETICAL MISSILE



contain a malfunctioned component or sub-system. But, typically, time does not permit the checking of all these parts. So the problem, as we see it, is to determine which tests to do in the limited amount of time, so as to maximize what we have called "commanders'confidence" -- (see chart 6 for definition).

To make this sort of design decision, we must be concerned with numerous factors -- such as the chance that a missile function, or group of parts, contains a malfunction; the chance of causing a failure by testing; the chance of finding or not finding a failure that is there; the chance that we call a good function bad; and the time that is required for each test.

Taking account of those factors that are appropriate, all of which can be estimated from reliability test data, we were able to define a "value" for each test. This value is with respect to the confidence requirement I defined. On the next chart (chart 7) we have plotted this value against the time required for each test, where a test could be concerned with one function, or a group of functions. Now that we have this plot of value against the time for each test, we are able to determine--graphically--those tests that are theoretically the best to perform in the limited time. To make these decisions we merly swing a ray, starting with the vertical axis, and pick up tests as we go down. The tests that we choose in this manner are those tests with the greatest value per time spent testing (the slope of the ray is value/time). We add up the time required for each test until the time allotted is filled. Here we have shown the 3, 4 and 5 min checkout lines, and the tests above the lines are those that comprise the theoretically best pre-launch checkout for these particular checkout lengths; i.e., these tests will maximize the commanders' confidence.

Chart 6

COMMANDER'S CONFIDENCE IS DEFINED AS:

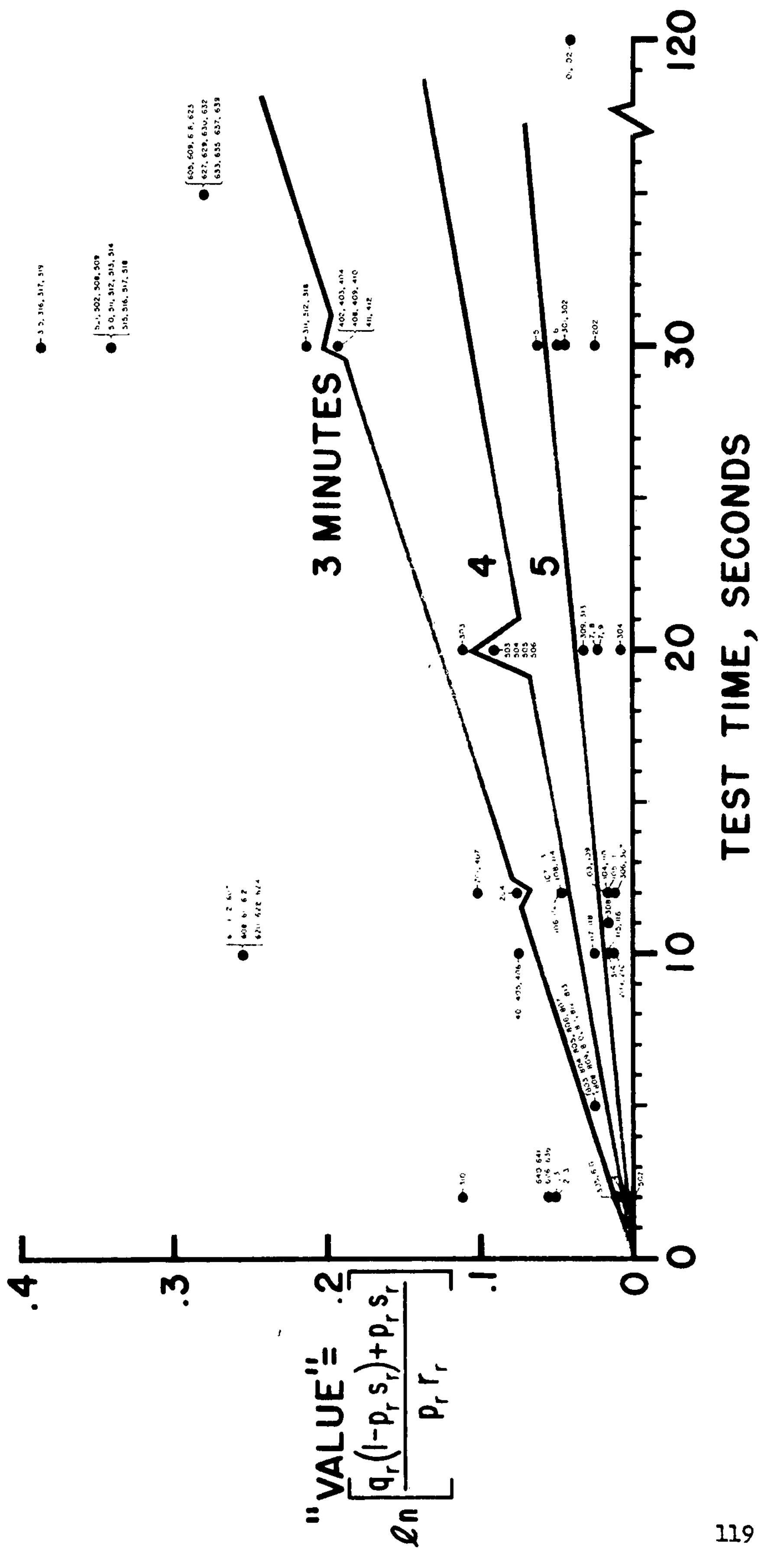
THE PROBABILITY THAT A MISSILE, FOR WHICH A LAUNCH ATTEMPT IS MADE, DOES NOT CONTAIN A MISSION-FAILURE CAUSING DEFECT.

OR

THE PROBABILITY THAT NO UNDETECTED MISSION-FAILURE CAUSING DEFECTS ARE PRESENT IN THE MISSILE AFTER CHECKOUT

Chart 7

PRELAUNCH CHECKOUT



There is a second stage to this decision process that takes advantage of test information on certain functions that is obtained essentially free by testing other functions. I'll not go through that method now, but it is a simple iterative process. This graphical decision technique, by the way, is a result of some pure research in mathematics, done here at RAND by George Dantzig some four or five years ago. It is essentially a linear programming technique.

Before leaving this topic, let me point out that we have shown this method to numerous Air Force organization staffs including BMD, and also to Martin, Convair, and STL. At the request of the BMD Titan office we worked with The Martin Company to apply the method to part of the Titan. As a result of this work The Martin Company is starting to use a modified version of this technique to design the pre-launch checkout of the Titan B. Persons at Convair are also looking into the possibility of using this method, both to evaluate the launch confidence of the Atlas and to help shorten their maintenance inspections. If either of these efforts are completed, and AF insistence on objective analysis in this important area would insure their completion, it will represent the first time that a quantitative statement of launch confidence could be made for an Air Force missile. It would also be the first time that any pre-launch checkout was designed to best satisfy its operational role, rather than to satisfy some design groups' subjective feelings.

This concludes my discussion of the things that we have done.

PRESENT EFFORTS

During this talk I have raised numerous issues or problems surrounding the design and employment of ACE; some I have been able to answer, while others have been left unanswered. Among the most prominent of the unanswered

questions are those that deal with the data and manpower implications of automatic testing. These are the areas of two of our present efforts.

I have already spoken of our study efforts in the data area. In the manpower area, we are concerned with the impact that this automatic equipment will have on Air Force manpower. How will it affect the number and skill level requirements for operations and maintenance? Are there any training benefits that can be derived or, as appears more likely, will more difficult training problems evolve? These questions, and others, are being addressed by primarily a case study approach in order to determine what preparation the Air Force should make for future increases in automation.

A second effort in the manpower area is looking at the proper roles for man and machine in test systems. There must be a man somewhere in each system; the question is, where should he be and what should he do? What provisions must be made for him, and what are the limitations on his capabilities to control and make decisions? We are presently gathering information on human factors and on the experience of organizations that have used automatic test equipment. Hopefully, from an analysis of this information we will be able to develop rules, or guides for the employment of man and machine in test and checkout.

The last unanswered problem area I want to mention is that of standardization of ACE. We all recognize that duplication of equipments that do essentially the same task is costly. Development time and dollars are needlessly spent; short production runs of specialty items give rise to higher procurement costs; and the use of specialty items rather than standard items reflects itself in higher over-all procurement, increased maintenance difficulties, and a need for increased training of maintenance

personnel. On the other hand, there are certain dangers that could result from a program of standardization. For example, information about a system is gained, in varying quantities, depending on the method of test employed for each function in the system. The adoption of standard, or universal, equipment could, then, degrade the test capability for some systems by essentially forcing them to adopt a non-optimum method of test.

This I believe presents the problem, and it is one that we are presently working on. Standardization of test equipment is not a new problem; it has been looked at by several groups starting with the R&D board in 1950. It is still largely unresolved, however.

The question that we are addressing can be stated as, is it feasible from economic and technical viewpoints to standardize automatic test equipment, and if so, at what level of aggregation? The work that we are doing on this issue is primarily conceptual and directed largely toward developing a framework within which specific standardization ideas can be evaluated. Hence, our work in this area should serve as a useful companion study to the work presently being done on SR-17530("Design Criteria for Automatic Test and Checkout Systems,").

CONCLUSION

In closing, I have tried to explore several of the more interesting problems facing us in the field of test equipment automation. Some questions I have been able only to raise but not answer. Our study is continuing, and in the near future we should be able to report on some of these unanswered questions.

ADEPT STUDY PROGRAM

Les Huldeman
Service Engineering Division
Dayton Air Force Depot

The subject of this talk is the "ADEPT Study Program". First of all, before I discuss the program, I will tell you what the name stands for. It is a coined abbreviation, derived from the words, "Air Force Depot Equipment Performance Tester." Actually, this title "ADEPT" does not completely describe the project, since the study has a two-fold objective.

The first phase of this study will produce a Performance Specification and a Model Specification for a Service Unit which will be compatible with the ATE which we presently have in the Air Force inventory. These specifications will incorporate building-block design concepts and plug-in module techniques, and will define the requirements for a Service Unit which will be capable of performing automatic malfunction analysis of the following seven Air Force electronic systems:

a. AN/ALT-6B Electronic Countermeasures Set

b. ARC-58 Radio Communications Set

c. ARC-65 Radio Communications Set

d. ARN-21 Radio Navigation Set

e. APN-59 Radar Navigation

f. APN-105 Radar Navigation Set

g. USM-26 Frequency Meter

These seven equipments were selected for this study because they were adjudged to be representative of those equipments being maintained by DAAFD. The Service Unit described by the specifications to be generated from this study will provide maximum flexibility and versatility with a minimum number of modules, and shall include all required stimulus generators, transducers, and automatic switching necessary to perform the desired tests. With a minimum of modification, the capability of this system could be extended to include all equipments in the DAAFD workload.

The second phase of this study which, incidentally, is not described by the coined title, will define the advantages to be gained by performance of automatic checkout with computer control and by the utilization of computer capability for the purpose of analyzing test results for detailed fault diagnosis. The following additional benefits, which could be derived from the application of computer methods, will also be described and explained by this study:

a. Automatic computation of limits based on previous measurements.

b. Automatic computation of limits based on applied stimuli.

c. Servo control of stimulus equipment.

d. Automatic fault isolation.

e. Faulty component isolation by rapid solution of complex circuit equations.

f. Simplified program modification.

g. Waveform analysis.

h. Automatic print-out of instructions for manual operations.

i. Improved logistic support through automatic stock control and reliability data processing.

j. Failure prediction.

We are convinced that a versatile electronics performance evaluation set can be employed by the depots to substantially reduce maintenance costs and improve the reliability of systems and components that have been repaired and re-evaluated with these techniques.

The use of automatic test equipment this past year on the AN/ARC-27 and the APX-6A and -25 equipments has saved the Air Force thousands of dollars by providing reliable equipment from existing aircraft instead of from new procurement. In the case of the AN/ARC-27 project, which I discussed in my earlier talk, more than 800 sets of unknown operating condition were automatically and rapidly evaluated. More than 300 of these were found to be functional.

During the APX testing operation, over 1100 units were checked with ATE, and almost 400 were found to be serviceable. These sets were immediately made available for use. We did not have to wait the normal long time for procurement and delivery.

Another benefit of such performance evaluation equipment is the reduction in repair time resulting from better diagnosis of faults within the unit under evaluation. This derives from rigid adherence to proper test routines and better reliability in making decisions, a characteristic of automatic performance evaluation equipment.

Now let's take a look at typical times presently required to test units and compare these with times which could be achieved with a versatile depot electronics performance evaluation capability.

In the case of the APN-59, the present depot test time is 8 hours and 30 minutes. Using automated techniques, this could be reduced to 42 minutes. The hook-up time does not delay a test if proper equipment is provided for alternating test fixtures. One unit can be connected and warm-up can be started while the other unit is being automatically evaluated.

In the case of other equipments, comparison of test times are as follows:

For the ARC-58, 13½ hours compared to 19 minutes;

For the ARC-65, 17½ hours against 27 minutes;

For the ARN-21, 6-3/4 hours against 1 hour and 10 minutes;

For the ALT-6B, 2 hours against 12 minutes.

In order to test a system, it must be connected to the proper power supplies and receive the correct inputs. The resulting outputs are measured and compared with required tolerances or limits. In the majority of the tests in today's tech orders, this evaluation is a simple comparison. In some cases a calculation must be made to evaluate performance. Because of this requirement we are carefully studying the application of automatic computing equipment to handle these cases. We are also

studying the use of computer control logic or control circuitry to simplify and speed up automatic performance evaluation. Our findings thus far indicate that computer techniques can be used advantageously. We believe that, in the next 5 years, computers will play an increasingly dominant role. We believe this so strongly that it is our recommendation that any ATE equipment purchased from now on should be compatible with computer control.

It is also our belief that a versatile performance evaluation set will involve a large number of service units in the beginning. It is, however, our conviction that as such equipment is applied in the field, better test procedures and improved signal generating equipment will evolve. This has already proved to be correct as far as AC and DC power supplies are concerned. A limited number of programmable supplies have replaced many power supplies of the fixed output type in other automated systems.

In establishing a versatile performance evaluation system, we find that the number of units required to test an added system becomes less as the total number of systems the set can evaluate increases. It is estimated that a set specifically integrated to test the systems referred to in this presentation can perform 85% of the tests on any other system to be encountered in the depot.

With this equipment we can introduce for the first time an auto-visual analyzer. This unit will so simplify piece part isolation that the actual test time will be reduced to minutes, rather than the hours required by present methods.

An analysis has been made of our logistic data handling system, AFM 66-1. The operator's console can include an IBM-type card punch control which will enable the set to completely coordinate with our over-all logistics system. Expeditious routing of reparable items through the logistic concept is assured.

It is interesting to note that in the case of the AN/ARC-27 tests being conducted by this depot, reliability of equipments tested by automatic test equipment, as compared to other methods, has shown considerable improvement.

Not only have we been able to substantiate the fact that satisfactory equipments reach the S.A.C. base, but the mean time between failure of AN/ARC-27 equipment has been notably increased.

The elimination of the human factor in test evaluation is an obvious logistic necessity.

FLIGHT EVALUATION OF THE RESULTS
OF
AUTOMATIC TESTING EQUIPMENT AND ITS ASSOCIATED TECHNIQUES

Frank J. Ruther
Chief, Service Engineering Division
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FLIGHT EVALUATION OF THE RESULTS OF AUTOMATIC TESTING EQUIPMENT AND ITS ASSOCIATED TECHNIQUES

by

FRANK J. RUTHER

INTRODUCTION

In the years since World War II, we have experienced a rapid growth in technology concerning Military Weapons Systems. This growth was due to the demand for more overall precision and generally higher standards of performance all through the life of the equipment being used. The higher performance continually expected of the equipment plus the complex functions which are a part of modern weapons systems have created a Pandora's box of maintenance problems.

The requirement that equipment be maintained on a "ready for action" basis can no longer be met with a multi-purpose meter, a standard signal and a tube tester. As a result, specialized support equipment has been developed to help maintenance reduce down time and aborted missions. It is estimated that the cost of support equipment has reached 70 percent of the total cost of the weapons systems. In many cases, the support equipment is specialized so that it also becomes obsolete with the weapon system.

In an effort to reduce the cost of ground support, to achieve standardization, and eventually to increase combat readiness, the Air Force is presently exploring the area of automatic testing equipment. One phase of this work is being conducted by the Service

Engineering Division here at Dayton Air Force Depot, where several types of automatic testing equipments are being evaluated at the depot maintenance level.

ADVANTAGES OF ATE

Now someone asks, "why should we do all this? What is to be gained?" the advantages that are usually presented are these:

1. Increased reliability
2. Uniformity of testing
3. Faster testing
4. Less skill required
5. Logistic control
6. More economical

The possibility of increasing the reliability of an equipment is of special importance to the military, and some proven facts to back up the theoretical gains are certainly required concerning the effect of ATE techniques upon reliabilities of operational equipments.

NEED FOR A CONTROLLED TEST

From the foregoing, it becomes obvious that a controlled comparison of ATE versus manual methods of testing is one of the steps required in order to determine the true worth of ATE and its associated testing techniques.

For the controlled comparison, it was decided that although bench testing would be cheaper, the proof of the value of different maintenance techniques would rest with actual performance of the sets in operating military aircraft. If sets repaired with the aid of ATE

provided no detrimental effect on equipment reliability or if it improved reliability in the environment of our front line aircraft, then a decision as to ATE's usefulness can be made based on cost considerations, ease and standardization of repair, etc.

With the decision to carry the evaluation to the field operational bases, we then have to consider how to collect the data necessary to arrive at decisions and conclusions concerning the objectives of our test. One method is to make out some forms which when properly filled out provide information on the hours of operation, conditions surrounding failures, and other items of a complete case history on each set assigned to the evaluation. These forms along with a quantity of equipments to be evaluated can be sent to an operating Air Force unit with instructions on how to proceed with the test. Then one only has to wait until sufficient data accumulates to do adequate analysis and you have your answer. In the past, all attempts to conduct tests in this manner have fallen apart due to lack of understanding, lack of communications and other lacks too numerous to mention. The equipments initially installed end up scattered all over, time records are in error or missing altogether and no conclusions are arrived at all. The worst part of such aborted tests is that irreplaceable time is lost to say nothing of the money that has been wasted.

A second method is to employ technical personnel who have the assigned responsibility for carrying out the field program of reliability and nothing else. These people should be skilled in the use of statistical tools which have been developed to help in arriving

at sound conclusions concerning whole populations of items although a relatively few may be tested. Also they must have engineering backgrounds to understand the use of the equipment and the environmental conditions which may affect equipment performance.

The second method has the following advantages:

1. Personnel concerned with the program can be given a thorough understanding of the objectives and expected accomplishments of the study;

2. A high interest in the study can be maintained in the field at the source of the data throughout the duration of the test;

3. As a result of their understanding of the study objectives and their close daily contacts with the system and with user personnel, field personnel can make decisions as necessary to keep the study on the right course;

4. Data supplied by field personnel, under conditions of close monitoring and recheck, require a negligible amount of rework and interpretation during analysis;

5. Selective attention can be given to developing details of trends that are pertinent to the evaluation;

6. Inconsistencies and errors in the data can be detected through checks and corrective action taken at (or close to) the time of occurrence;

7. The work of data collection is taken off of the military personnel who have the prime responsibility of keeping fighting aircraft ready to go.

The foregoing list is not complete but represents some of the more important reasons for assigning technical and administrative conduct of controlled field studies to personnel skilled in the concepts of sample testing.

Another factor essential to the success of the field study is a detailed written document which is in effect a "work statement" for the work to be done during the field study. This study work statement, if properly planned and written, is the primary medium for coordinating the plans of the project engineering group and the measurement, data-collection, and processing work of the field group. If the over-all evaluation program is of such magnitude that several people are assigned to the study, either in the same or in different field locations -- or if there is any possibility of personnel dislocation during the course of the study -- a clearly written work statement serves to protect the original objectives of the test.

The final essential item in the success of any field study in military aircraft is to have the approval and support of the military authorities at the sites selected and their headquarters group. The test should be conducted so that no interference with the military operations result. An important portion of the study is to make the evaluation in the environment of the aircraft as used by the military. If we dictate how the aircraft must be used or how maintenance should be done for purposes of the study, we may well change the environment from normal usage. These conditions must be maintained throughout the duration of the test.

Late in 1959 we of the Service Engineering Division here at DAAFD studied the possibilities for just such a controlled comparison, and later, awarded a contract to ARINC Research Corporation of Washington, D.C., for a comparison of the field of reliability of manually processed RT-178/ARC-27, airborne receiver-transmitter unit, with those tested and repaired using ATE.

To avoid any chance of bias, it was decided to use the services of an independent agency to conduct the field evaluation for comparing performance of the two groups of sets. This was considered important since at the present state of development, most people working with ATE have developed rather strong feelings either for or against the equipment in use.

In addition, ARINC Research Corporation had available a trained Field Organization using proven data collection techniques, and experienced in working at Military Bases. In the following discussion, it should be noted that the RT-178 transceiver unit is not itself being evaluated, but is merely being used as a gauge for measuring the relative effectiveness of the ATE and manual testing and repair techniques.

SPECIFIC TEST PLAN

As stated previously, the general objective of this study is to determine if improved field reliability results from the using of ATE in the test and repair of transceiver units. With this in mind, we will examine the test plan in detail, and then consider the specific objectives. The test plan description is as follows:

One hundred and forty transceiver units were selected at random from those returned to the depot, and divided into two groups of 70 each; those to be initially repaired by the depot shop with the aid of ATE, and those to be initially repaired by the depot shop using manual methods. These groups were subsequently sub-divided to create the four test segments shown in Chart 2. The quantities were determined from previously measured failure rates and standard statistical techniques.

Sets assigned to each test segment were equally divided between the two types of aircraft (B-47 and KC-97) to provide equal chance of survival of each test group in case the different aircraft provide sufficiently different environments to affect set failure rate. In order to protect the test design of approximately equal quantities of sets from each test category, sufficient spares are provided to prevent switching of sets from aircraft to aircraft or installing too many of one category due to a concentration of failures in another group.

The actual plan for installing the units in operational aircraft is shown in Chart 3. Control of initial and subsequent installations is being maintained by ARINC Research Corporation field personnel to assure equal accumulation of operating time by the various groups, and to obtain maximum operating time for those units initially installed. In addition, these personnel are responsible for keeping accurate records on the history of each set in the test. These records include hours in service, conditions surrounding malfunctions, maintenance action taken and retest results on any parts replaced.

TEST OBJECTIVES

Now that we have reviewed the test plan, we will consider the specific objectives of the test.

The first objective is to establish the reliabilities of the transceivers maintained by the various methods shown on Chart 2.

1. Test segment number one consists of transceivers tested and repaired by means of ATE only.

2. Test segment number two consists of transceivers initially tested and repaired by means of ATE and subsequently by field shop personnel.

3. Test segment number three consists of transceivers tested and repaired manually by the depot shop only.

4. Test segment number four consists of transceivers initially tested and repaired manually by the depot shop and subsequently by the field shop.

The word "subsequently" in the case of segments 2 and 4, means "after a first installation of a transceiver in an operational aircraft".

The second objective is to determine the reliabilities of transceivers in terms of "mean time to failure" and distributions of "mean times to failure".

The third objective is to collect and analyze failure and flight data to determine how failure patterns are influenced by different maintenance procedures.

TEST RESULTS

Although the test is now completely installed and the data collection is proceeding satisfactorily, no positive trends have yet been established as far as the main objective of the test is concerned -- that is, the mean times to failure of the transceiver unit in operational usage -- so, to avoid any possible misinterpretation, the presently available figures will not be given at this time.

Two interesting sidelights worthy of note, however, were revealed during the initial processing of transceivers at the depot prior to shipping them to the field.

First, approximately five times as many parts were removed from transceivers processed by ATE as from manually processed units.

Forty parts and tubes, on the average, were removed from the units processed through ATE, whereas an average of only eight parts were removed from the manually processed units. Possible reasons for this difference are as follows:

It is worthy of note that all transceivers processed through ATE were subjected to dis-assembly, static and dynamic testing of sub-assemblies, cardomatic test of tubes, and then reassembly, adjustment and alignment -- regardless of whether they passed or failed the initial DATICO check.

The transceivers in the manually processed segments were given only a routine "in-the-case" check and then reworked only as required to correct any cause for rejection found.

The implication here is that there is an average of 32 "out-of-tolerance" parts remaining in the manually accepted units which could

have been detected by present ATE techniques. The actual quantity will be somewhat less than the 32, as I will explain later.

Second, verification of ATE rejected parts is high. Approximately 80 percent of the resistors and capacitors rejected by ATE were found to be defective during subsequent lab tests.

While this percentage may seem low, it is quite satisfactory when you consider that a single ATE test often checks two parts simultaneously and that both parts which might have caused the out-of-tolerance ATE read-out are removed rather than spend additional time doing manual trouble-shooting.

Since all of the parts removed during ATE processing are not, in fact, out-of-tolerance, it follows that the actual quantity of bad parts remaining in the manually processed units may be less than the 32 parts mentioned previously.

The percentage of tubes rejection confirmed by lab tests was only 30 percent. This low percentage caused considerable concern and a resultant investigation revealed that the programmed limits for the Cardomatic Tube Tester vary from the MIL-E-1B limits due to special cards used for critical RT-178 tube sockets. A review of data should present a more favorable percentage.

Only tubes, resistors, and capacitors have been lab checked at this time. Other components may be subjected to lab checks when sufficient quantities have been accumulated.

IMPORTANT FINDINGS

Thirty percent of the manually tested units were rejected by SAC bench tests while over 90 percent of ATE tested units were accepted

by SAC bench test. This fact alone may justify all out use of ATE.

PROBLEM AREAS

Although the controlled test has not been in progress long enough to develop any firm trends as far as the main test objectives are concerned, it has run long enough to point out some of the major problems involved in the use of ATE. The problem areas which I will mention are the usual ones which have been discussed at length before so I will only give a brief statement on each at this time.

One, programming and tolerance determination for automatic testing is still in a rather primitive state of development -- much of it being done on a trial and error basis. This problem will probably resolve itself as more and more experience is gained with ATE. It is likely that engineering requirements will eventually develop a large pool of talent in the field of ATE programming in the same manner that it did in the field of computor programming.

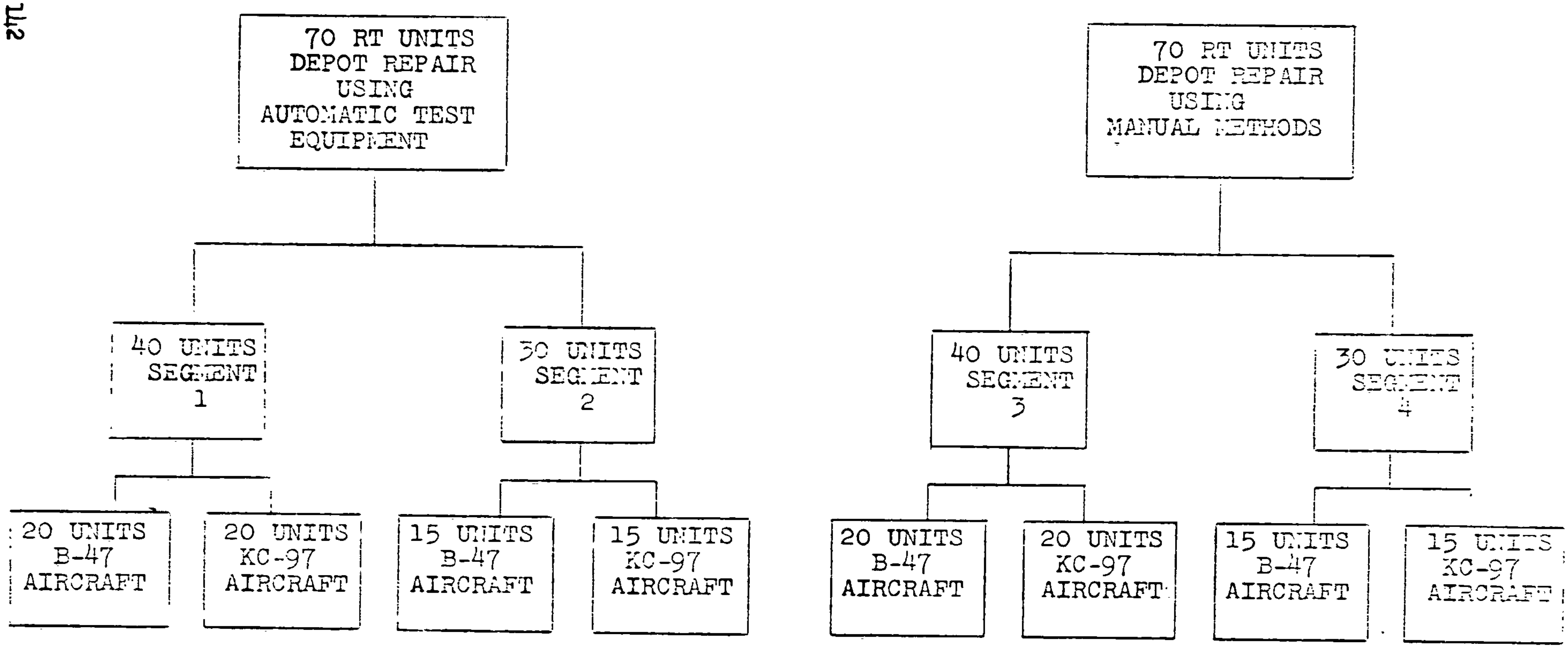
Two, the major problem in utilizing ATE to test RT-178 units and sub-assemblies is that the RT unit was not designed to be tested in this manner (or any other manner). Consequently, physically locating test points and connecting test leads to them tends to reduce to time advantage which is inherent with use of ATE.

Finally, the need for reliable components in the ATE itself is especially pointed. A failure in an ATE module might cause several units of equipment under test to be rejected and disassembled before the ATE was suspected, or,which is worse bad sets may be passed and put into operational aircraft or missiles.

CONCLUSION

Before closing, I would like to mention that the Service Engineering Division is in the process of adding three additional test segments, 5, 6, and 7, to the current test. These segments are designed to evaluate 2 additional levels of ATE maintenance techniques and to determine the reliability and maintainability of DATICO Model DAT-001.

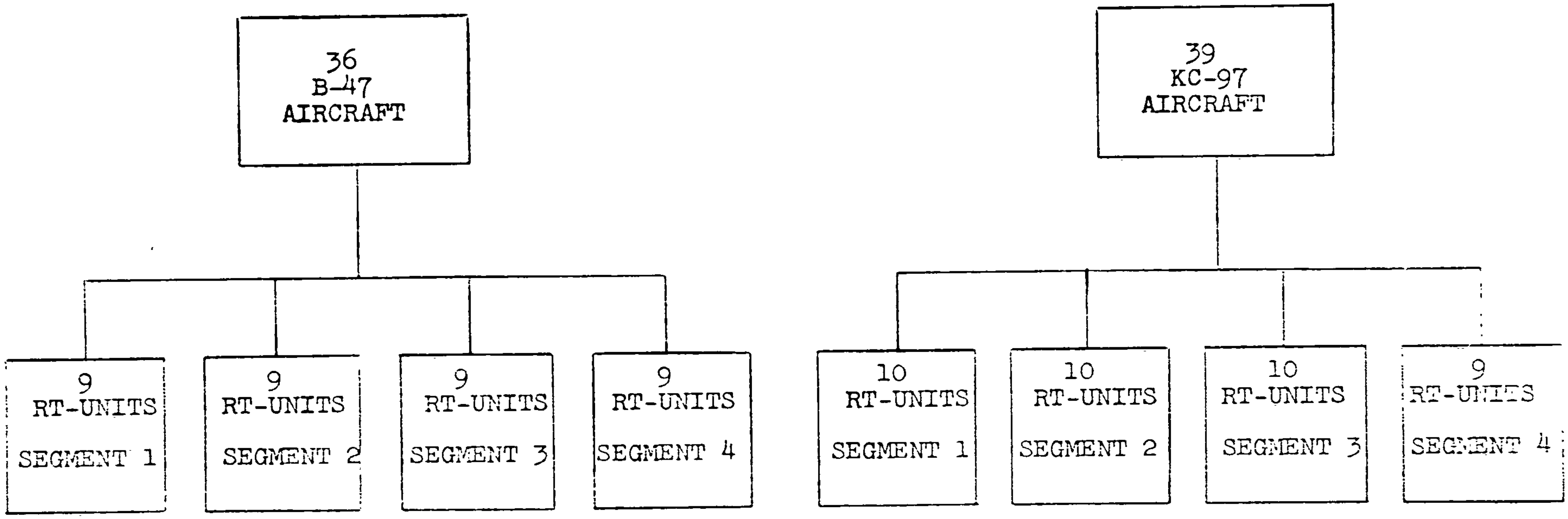
I hope that by the time of our next meeting, we will have progressed sufficiently in these controlled tests to make some positive statements about the mean times between failures, and the failure distributions of manually processed transceivers and the ATE processed units.



SEGMENT 1 -- RT UNITS RETURNED TO DEPOT FOR ALL MAINTENANCE BY ATE.
SEGMENT 2 -- RT UNITS REPAIRED INITIALLY BY ATE; SUBSEQUENTLY BY FIELD MAINTENANCE
SEGMENT 3 -- RT UNITS RETURNED TO DEPOT FOR ALL MAINTENANCE BY MANUAL METHODS
SEGMENT 4 -- RT UNITS REPAIRED INITIALLY BY DEPOT MANUALLY; SUBSEQUENTLY BY FIELD MAINTENANCE

CHART 2

TEST PLAN
RT-178/ARC-27 ASSIGNMENT



SEE FIGURE 2 FOR DEFINITIONS OF SEGMENTS

CHART 3

TEST INSTALLATION PLAN
AIRCRAFT ASSIGNMENT

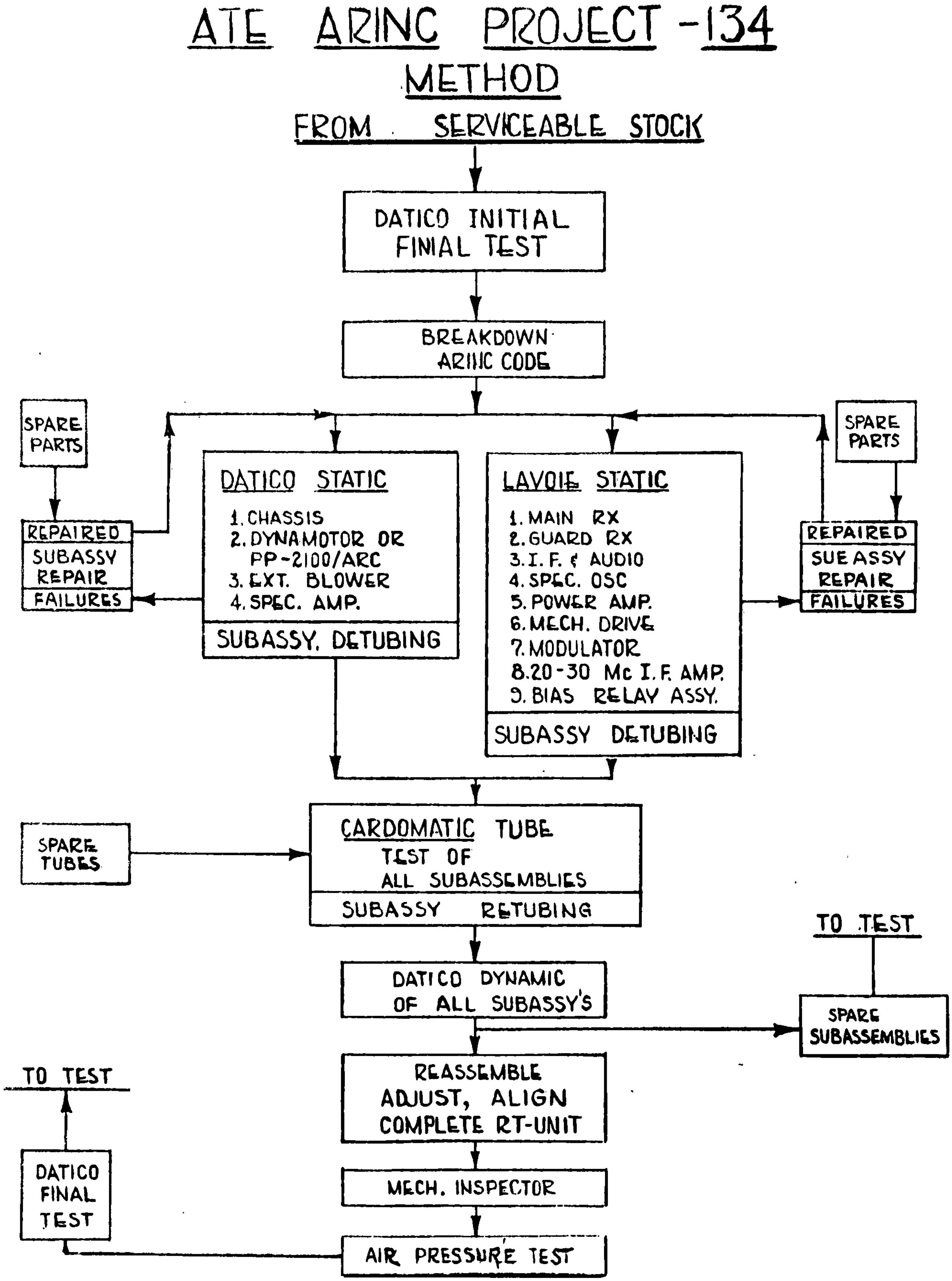
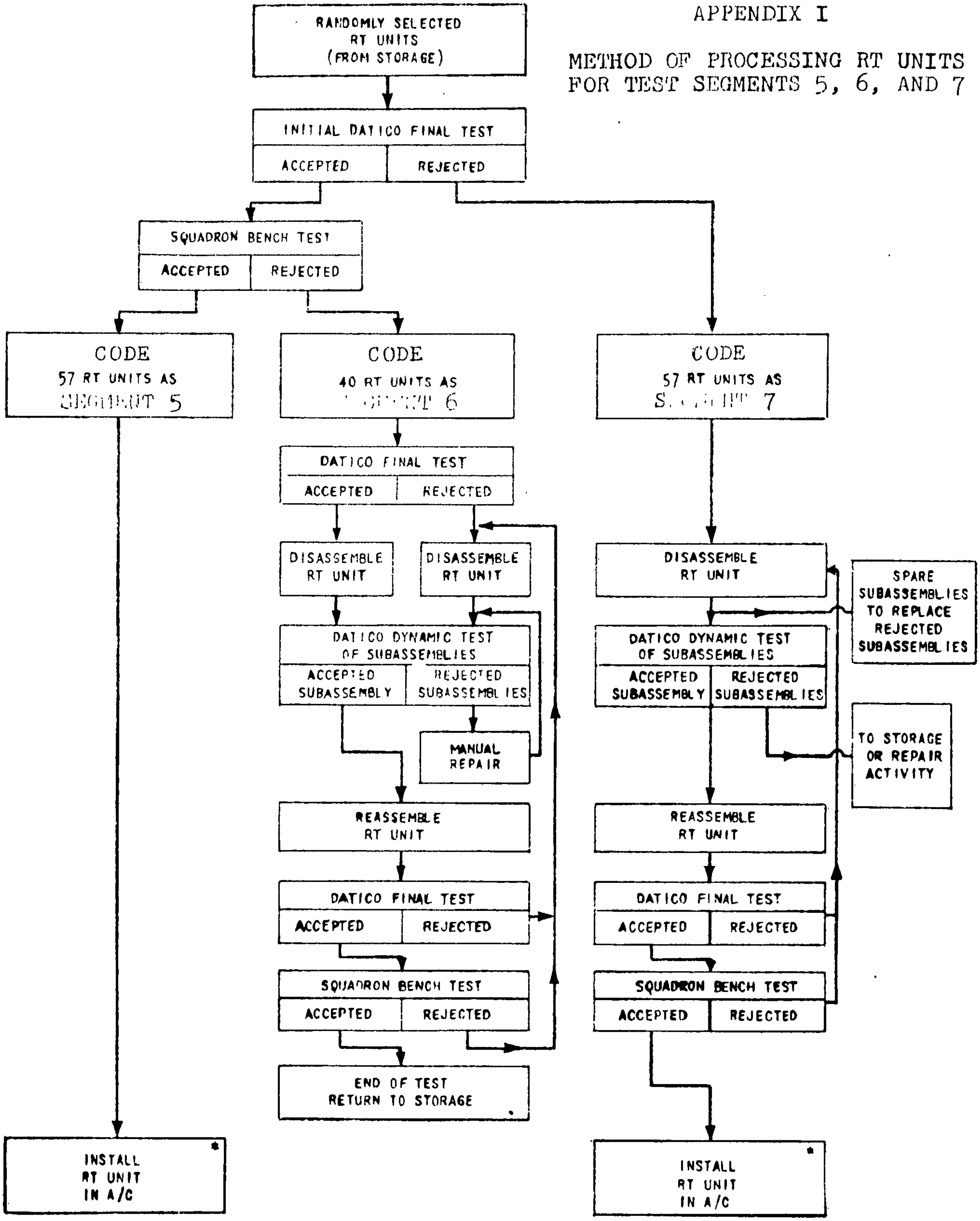

ATE ARINC PROJECT -134
METHOD
FROM SERVICEABLE STOCK
DATICO INITIAL FINIAL TEST
BREAKDOWN ARINC CODE
SPARE PARTS
REPAIRED
SUBASSY REPAIR
FAILURES
DATICO STATIC
1. CHASSIS
2. DYNAMOTOR OR PP-2100/ARC
3. EXT. BLOWER
4. SPEC. AMP.
SUBASSY. DETUBING
LAVOIE STATIC
1. MAIN RX
2. GUARD RX
3. I. F. & AUDIO
4. SPEC. OSC
5. POWER AMP.
6. MECH. DRIVE
7. MODULATOR
8. 20-30 Mc I. F. AMP.
9. BIAS RELAY ASSY.
SUBASSY DETUBING
SPARE PARTS
REPAIRED
SUB ASSY REPAIR
FAILURES
SPARE TUBES
CARDOMATIC TUBE TEST OF ALL SUBASSEMBLIES
SUBASSY RETUBING
DATICO DYNAMIC OF ALL SUBASSY'S
TO TEST
SPARE SUBASSEMBLIES
REASSEMBLE ADJUST, ALIGN COMPLETE RT-UNIT
TO TEST
DATICO FINAL TEST
MECH. INSPECTOR
AIR PRESSURE TEST

CHART 4

APPENDIX I

METHOD OF PROCESSING RT UNITS FOR TEST SEGMENTS 5, 6, AND 7



* RT UNITS FAILING SUBSEQUENT TO INSTALLATION SHALL BE SUBJECTED TO MANUAL REPAIR

CLOSING REMARKS
by

John W. Riggs, Colonel, USAF
Chief, Ground Support Equipment I/M Division
Dayton Air Force Depot

CLOSING REMARKS BY COLONEL JOHN W. RIGGS

We have tried to show you what we at Dayton do; what we have contracted; and, to a degree, what the Automatic Test Equipment (ATE) offers us; what it offers the other services. We have shown you our application of the ATE in the Inertial Guidance System at Heath. The VATE program. In our charge with the ATE, we feel that the VATE program is a part of what we are charged with along with the program. You have been to our shops. You have seen our ATE in operation. Our down time is getting shorter and shorter. It may be advantageous for us to go back and have the machine modernized. We have tried to give you the objectives as we see them in ATE and the status of our studies. We have given you everything that we have, to my knowledge. We have talked about reliability and versatility studies.

We feel that all of you need us, and I know that we need you and we will do anything within our power to attain your help. We cannot make it alone. I think the most that you can give us and the most that we can give you is our mutual desire to reach a goal. We must have a mutual understanding. This is one purpose of our Symposium. We feel that we have a lot of useful data here and we want to make distribution of it. When you leave here, you will receive this folder which contains a copy of all the presentations made today. Any other information that we have here we want to pass it out. Just let us know and we will do it. We would like to find out who at what depot is monitoring the ATE program.

We want to find out who we call; who we talk to. Please let us know the chain of how we get to you. If you want to know something from this Depot, send your inquiry to me and I will see that it gets to the proper person. We would like to get your thoughts on what information you think we should exchange. We don't know just what information would be best to give you. We think that you have information we should have. There are many instances when people can do something for you and would be glad to do it for you if they only knew you wanted them to. We feel that we have only a basic feel for the preliminary operational concept of ATE. I cannot stress too much that we feel that we are in the embryo state. I don't believe we have travelled 10% of the distance yet. I would like to know what to present to the weapons phasing groups. What we can do for them - how that they can utilize what we are giving them. I would like to know how we can augment their program. What, when, how, etc. We are going to have to give a lot of thinking to mock-up inspections. We are going to have difficulty for a while in the stock numbering, parts numbering, etc. That is a minor problem that we will resolve within AMC. We would like to give you and receive from you any specification, any data, that you in the Army or Navy or any other area have or may know about. I believe if we can get the information from you as to where the contact point is, and if you will let us know who to see where, we will get our data out to you promptly. Some of you are from an area that has access to a lot of money. I don't know how much money we will get, or when we will get it, but before we meet again we want to come to some kind of plan on that. I hope to give you a resume on the money picture when we meet again.

ATE SYMPOSIUM
ROSTER OF ATTENDANCE

WASHINGTON D C

Mr. John R. Taylor - Office of Secretary of Defense
Lt. Col. Anthony Quesada - Hqs USAF Pentagon
Mr. James Grodsky - OSD, ODOR&E

DEPT OF NAVY

Mr. B. L. Poppert - Bureau of Ships, Washington, D. C.
Mr. Hallet Saunders - Bureau of Ships, Washington, D. C.
Mr. J. P. Maynard - Bureau of Ordnance, Washington, D. C.

DEPT OF ARMY

Mr. Marion Anderson - U. S. ARGMA Redstone Arsenal, Ala.
2nd Lt. John Neidhart - Redstone Arsenal, Alabama

COMMAND'S

Major Robert L. Harriman - SAC Offutt AFB, Nebraska
Mr. E. L. Herndon - MATS Scott AFB, Missouri

AMA'S

MAAMA

- Mr. James Bartlett
- Mr. James Callaghan
- Mr. Lester Millman
- Mr. Lester Ratcliff

ROAMA

- Mr. Walter Thoni
- Mr. Frank Benvenga

WRAMA

- Mr. Richard Snyder
- Mr. O. R. Bailey
- Mr. Richard Jackson

SAAMA

- Mr. Robert Patton
- Mr. Robert W. Elwell

SMAMA

- Mr. Edward Beyers